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A mission statement

To meet the need for a high quality scientific publishing platform in its field, the International Association of Research Organizations for the Information, Media and Graphic Arts Industries is publishing a quarterly peer-reviewed research journal.

The journal is fostering multidisciplinary research and scholarly discussion on scientific and technical issues in the field of graphic arts and media communication, thereby advancing scientific research, knowledge creation, and industry development. Its aim is to be the leading international scientific journal in the field, offering publishing opportunities and serving as a forum for knowledge exchange between all those interested in contributing to or learning from research in this field.

By regularly publishing peer-reviewed, high quality research articles, position papers, surveys, and case studies as well as review articles and topical communications, the journal is promoting original research, international collaboration, and the exchange of ideas and know-how. It also provides a multidisciplinary discussion on research issues within the field and on the effects of new scientific and technical developments on society, industry, and the individual. Thus, it intends to serve the entire research community as well as the global graphic arts and media industry.

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- Packaging
- Fuel cells and other printed functionality
- Printing on biomaterials
- Textile and fabric printing
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- Colour reproduction and colour management
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- Media industry developments
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- Online and mobile media development
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Social impact

- Media in a sustainable society
- Environmental issues and sustainability
- Consumer perception and media use
- Social trends and their impact on media

Submissions to the Journal

Submissions are invited at any time and, if meeting the criteria for publication, will be rapidly submitted to peer-review and carefully evaluated, selected and edited. Once accepted and edited, the papers will be published as soon as possible.

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A letter from the Editor

Gorazd Golob
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This year's second issue of the journal is ahead of us. Despite the delay in publishing and a small volume of articles, I would like to post the important news. Since this year, the journal is indexed also at Clarivate Analytics. In July, we received an Acceptance letter informing us that the Journal has been selected for coverage in Clarivate Analytics products and services. The Journal is now indexed and abstracted in the Emerging Sources Citation Index (ESCI). ESCI complements the highly selective indexes by providing earlier visibility for the sources under evaluation as part of the Science Citation Index Expanded™ (SCIE), the Social Sciences Citation Index® (SSCI), and the Arts & Humanities Citation Index® (AHCI).

In 2017, Clarivate Analytics was launching ESCI, which will extend the number of journals and other publications in Web of Science to include high-quality, peer-reviewed publications of regional importance and in emerging scientific fields. ESCI will also make content important to funders, key opinion leaders, and evaluators visible in Web of Science Core Collection even if it has not yet demonstrated citation impact on an international audience. Inclusion in ESCI provides more discoverability which leads to measurable citations and more transparency in the selection process.

The Journal of Print and Media Technology Research, like other journals in ESCI, have passed an initial editorial evaluation and can continue to be considered for inclusion in products such as SCIE, SSCI, and AHCI, which have rigorous evaluation processes and selection criteria. All ESCI journals are indexed according to the same data standards, including cover-to-cover indexing, cited reference indexing, subject category assignment, and indexing all authors and addresses.

The classification in ESCI has proven the correctness of the decision of the Board of iarigai to begin with publishing of the Journal of Print and Media Technology Research in 2012 and was successfully implemented by the first editors Nils Enlund and Mladen Lovreček. The Journal is now the first periodical publication, primarily covering print and media, that is indexed and covered by Clarivate Analytics, an internationally recognized bibliometric data provider. One of the milestones of the journal is almost reached and it only depends on us when and how we will achieve the classification in the undisputedly desirable SCIE database of scientific journals with Impact Factor.

The Journal is now under the observation, so quality of published papers, respect for ethical standards and rules of scientific publication, the volume and regularly published issues will affect our further destiny. Interdisciplinary orientation, rigorous review procedures and careful editing will remain a key feature in the future.

There are three articles published in the current issue. The first research paper deals with the UV-ozone surface treatment of flexo printing plates, which represents an important novelty in the development of methods for improving the quality of prints, by varying the surface free energy and the polarity of the surface of the printing elements. Of course, the article opens up new questions and challenges, which is also the purpose of publishing the results of research work. The second case study paper shows an overview of colour management issues on modern tablet devices, which undoubtedly represent an opportunity and a challenge even in professional use, although they were originally intended primarily for the broad consumer market. The third review paper provides an overview of the possibilities of introducing modern methods of Data Analysis based on Big Data, which is already implemented in paper and other industries. Systematic introduction and definition of those methods with practical examples of current and potential new uses in the field of packaging printing and thus also in the field of general printing industry are shown.

In the Topicalities, edited by Markéta Držková (marketa.drzkova@jpmtr.org), excerpts from some recently completed EU-funded research projects where printing technology was included as a part of the research work, are presented; together with new market reports and surveys from the field. In the Bookshelf new books covering nanomaterials, light and colour, QR codes, design, conducting polymers and sustainability issues are introduced. Three abstracts of doctoral theses are showing the research results in printed electronics, device physics and photography. The listed events show the worldwide interest for research results and business opportunities in printing technology, nanomaterials, printed electronics and functional printing, together with packaging and label printing.

One of the forthcoming events is the traditional 44th International iarigai Conference: Advances in Printing and Media Technology, hosted by iPrint Institute of the School of Engineering and Architecture Fribourg, Switzerland. Many authors, reviewers and editors of the Journal will attend this event and we are expecting interesting contributions from different research fields including industrial printing and printing processes, printed functionality, printing inks, substrates and quality. We hope that some ambitious authors will decide to present their achievements in the future as extended and supplemented research papers on most interesting topics, in the Journal.

Ljubljana, July 2017

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Modifying the qualitative properties of print by surface treatment of flexographic printing plate

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Abstract

In the fast-pace technology development in graphic industry, modern flexography has found its domain mostly in the packaging sector and it is increasingly of interest for functional printing. Functional printing has a relatively low market value but greater interest in research. Due to the new qualitative requirements, workflows and materials used in flexography had to be updated and improved. The application of digitally controlled processes and procedures has taken the place of the analogue production, together with the new methods of material processing and improvements of the materials themselves. This research focuses on the functional modification of photopolymer flexographic printing plate's properties with the aim of achieving optimal output quality. During the transfer of the printing ink from the anilox to the printing plate and then to the printing substrate, surface properties of the printing plate influence the quality of the print. Therefore, surface properties of the printing plate should be compatible with the used printing ink and the printing substrate, which is especially important when using new formulations of inks and experimenting with different printing substrates and applications, for example in functional printing. In this research, samples of photopolymer flexographic printing plates were exposed to UV-ozone treatment in order to modify the surface properties of the photopolymer material. Results have displayed significant changes in surface free energy of the photopolymer material when the printing plate samples were exposed to the UV-ozone for periods up to 5 minutes. In order to analyze the quality of the prints produced with UV-ozoned flexographic printing plates, test prints were produced. Prints produced with printing plates with longer UV-ozone treatment have displayed the qualitative changes in the reproduction of fine printed elements, i.e. the width of fine lines, coverage values, ink volume on print and the definition of the shape and edges of printed elements. Changes of named properties of the print are significant for conventional, and in many cases for functional printing. Performed research proved that the functional modification of flexographic printing plates with the aim of improving the print quality is possible. The UV-ozone treatment is a procedure where the printing plate is exposed to significantly higher energy than with conventional UVA and UVC tubes. Therefore, the duration of the UV-ozone treatment must be precisely adjusted in order to maximize the quality of the print, while at the same time maintaining printing plate's functionality.

Keywords: flexography, photopolymer, UV-ozone, surface free energy, ink transfer

1. Background

Flexography is a printing technique mostly used in packaging and functional printing. Flexographic printing plates are made of photopolymer materials, formulated to meet mechanical and qualitative requirements in the graphic reproduction process. In the significant part of its domain, flexography is competing with gravure printing. In the past few years, there have been some gains in share over gravure printing because of the greater flexibility of the prepress in flexography, as well as for the jobs with shorter run lengths, frequent design changes and special functional applications (Bodwell and Scharfenberger, 2011; Phillips, et al., 2012).

Many parameters influence the quality of the final product in flexography: photopolymer material used for the printing plate production (Matsubara and Oda, 2013),

quality of the file adjustment, type of anilox roller, type of tape placed under the printing plate to adjust the elastic deformation of the printing plate, properties of the printing ink and printing substrate (Bollström, et al., 2012; Bollström, et al., 2013; Aspler and Lepoutre, 1991), control of the printing process, and a set of parameters associated with the printing plate production (Mahović Poljaček, et al., 2013).

Flexographic printing process has achieved significant improvements in the quality of the printed product. The automation of the printing process ensured better control over the output. Printing inks and anilox technology improved in quality as well, but the main improvements have been made in the area of printing plates and imaging methods (Bodwell and Scharfenberger, 2011; Esko, 2012). New formulations of photopolymer materials enabled production of smaller dots on the printing plates, in some cases even being able to eliminate the bump curve, resulting in higher quality prints in the highlight area and expanded gamut. Photopolymer materials used nowadays have increased resistance to solvents and ozone, and are compatible with solvent-based, water-based and UV-curable inks. Furthermore, new technologies in the flexographic printing plate processing workflow enabled the production of "flat-top" dots (Esko, 2012). However, the debate about superiority of this shape of printing element over the "bullet-shaped" dots exists (Asahi, 2015).

Furthermore, new formulations of photopolymer materials used in flexographic printing plate production enabled increased ecological sustainability of the processing. Water-washable printing plates eliminated the use of the volatile organic solvents from the printing plate production process (Anderson & Vreeland Inc., 2017; Asahi Photoproducts, n.d.; Flint Group, n.d.). Mechanical (chemistry-free) process of engraving the polymer material in the printing plate production was re-introduced to flexography as well. In the graphic reproduction process, the transfer of the printing ink from the anilox to the printing plate and finally to the printing substrate depends on the surface properties of the materials used. Since the printing plate is in the middle of the ink transfer chain, its surface free energy (γ) must be adequate to achieve the optimal transfer of the printing ink from the anilox to the printing substrate (Mahović Poljaček, Cigula and Tomašegović, 2012; Page Crouch, 2005). Improvements of the flexographic printing plate's surface properties in the past decade have been made as well. Patterned textures have been applied to the surface of the printing elements on the printing plate in the plate making process (Kodak, 2014). The surface of the printing plate roughened in this way enables better adsorption of the printing ink to the printing plate, and better transfer of the ink to the printing substrate, reducing the fingering. However, flexographic printing plate manufacturers have several approaches to the cause-effect relation of the surface properties of the printing plate and the quality of the print (Asahi Photoproducts, n.d.; Flint Group Flexographic Products, n.d.).

Furthermore, γ of the printing plate can be modified in the standard printing plate production workflow if needed, during the post-treatment process (Mahović Poljaček, et al., 2014). Previous research (Tomašegović, Mahović Poljaček and Cigula, 2013; Tomašegović, Mahović Poljaček and Leskovac, 2016; Mahović Poljaček, Tomašegović and Gojo, 2012) has indicated that UVA and UVC post-treatments influence the printing plate's physico-chemical surface characteristics by changing the components of γ of the photopolymer material. This influences the transfer of the printing ink from the anilox to the printing plate and from the plate to the printing substrate (Mogg, et al., 2016).

In previous research (Mahović Poljaček, et al., 2014, Mahović Poljaček, et al., 2016), energy dispersive X-ray spectroscopy (EDS) analysis showed that the changes in contact angles of probe liquids and γ are caused by the increase of oxygen concentration in the surface layer of the printing plate, while FTIR-ATR analysis pointed specifically to the increased ratio of carbonyl and hydroxyl bonds (Tomašegović, Mahović Poljaček and Cigula, 2013). Therefore, duration and intensity of the post-treatment process must be strictly adjusted and regularly monitored. Modifications of the printing plate's properties during the UV post-treatment depend on the type of the photopolymer material and should be performed in the printing plate production workflow in accordance with the type of the printing ink and printing substrate used. Since standards in flexography are mainly focused on the process control concerning screen ruling and parameters connected to process colours, printing substrates and dot gain (International Organization for Standardization, 2012), further analysis and experiments are yet to be performed when considering the influences of the printing plate quality on the graphic reproduction process.

The aim of this research is to determine the influence of the printing plate's surface modification, precisely, the influence of the UV-ozone treatment, on the surface properties of the printing plate specifically related to the quality of the prints. The UV-ozone treatment of the flexographic printing plate, due to its higher energy, is a rapid method compared to the modification of the regular UVA and UVC post-treatments and presents a new method for adjusting the properties of the prints in relation to the specific printing system. Improvements and adjustments of qualitative properties of the print obtained by UV-ozone treatment have the potential to be useful in conventional and functional printing.

2. Experimental settings

For the purpose of this research, samples of Mac--Dermid LUX ITP 60 printing plate were received from MacDermid Printing Solutions. This plate is a solvent-washable, CtP flexographic printing plate with thickness of 1.14 mm. Printing plate samples used in this research were produced in the standard conditions by the printing plate manufacturer (MacDermid, 2014). The objective of the research was to determine the effect of the UV-ozone treatment on the surface properties of the printing plate, as well as the quality of the prints obtained by modified printing plates. Therefore, two sets of samples for each type of printing plate were produced:

- fields with 100 % surface coverage;
- samples with applied control elements which consisted of different fine elements, special elements and strips, as well as control wedges with halftones from 1 % to 100 % coverage value (Figure 1).

Motives were transferred on all printing plate samples with the application of the same compensation curve – FlexoSync 56. White opaque Melinex, with thickness of 350 ± 4 μm and γ of 42 mJ/m^2 was used as a printing substrate.

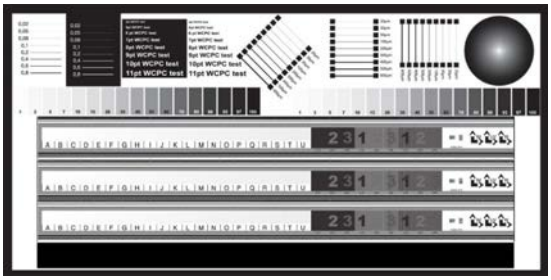


Figure 1: Set of control elements on tested printing plate samples

To ensure that the printing process was consistent in terms of the printing pressure (and other parameters), elements from three DFTA (2006) strips (Figure 1) were microscopically analyzed. After ensuring by microscopy that the transfer of the DFTA strip from the digital file to the printing plate was correct, three positive and negative lines surrounding the DFTA strip were observed and analyzed on the print, as well. These lines make it possible to check how stable thin lines are over various production runs. They enable to check the capability of the plate to hold straight the isolated line during the pressure in the printing process. Due to their sensitivity to the changes in the printing conditions, microscopic analysis of their shape was used to make sure that the deformations due to the variation of the pressure did not occur during the printing process and that the lines remained straight, with the similar and unchanged shape.

The UV-ozone treatment of the printing plate samples was performed in a NOVA SCAN PSD Pro Series Digital UV Ozone System; UV lamps in the NOVA SCAN PSD generate UV light at wavelengths of 185 nm and 254 nm, the instrument also produces O_3 and provides molecular excitation (NOVASCAN Technologies, n.d.).

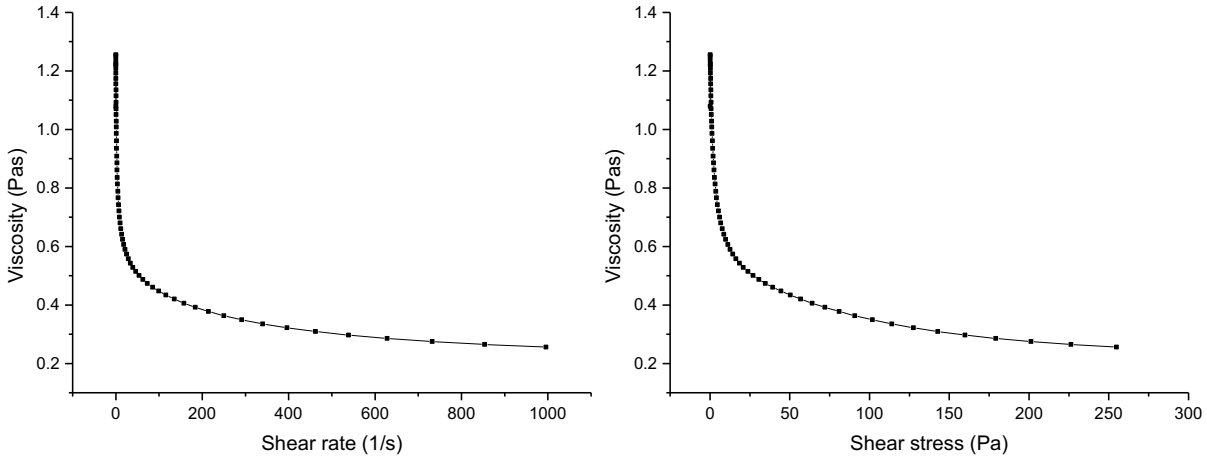
All samples of printing plates were treated by UV-ozone for up to 5 minutes (0.5, 1, 1.5, 2, 3 and 5 minutes).

Topographic analysis of the printing plate samples and prints was performed by means of the white light interferometry using a WYKO NT – 2000 White Light Interferometer, which was also used to calculate the roughness parameters of the printing plate surface. The profile and surface of the structure can be measured without contacting the sample, which can greatly minimize the chance of destroying the fragile structures. Vision 32 software was used to calculate the width of printed fine lines, surface coverage and ink volume on the prints (Wyant, 2002).

Roughness of the solid-tone areas on prints was measured by portable roughness tester TR200 ten times on different spots on each sample, in order to identify the changes in the uniformity of the printed ink layer as a consequence of the UV-ozone treatment of the plate.

On the printing plate samples, contact angles of different probe liquids were measured by means of Fibro DAT 1100 Dynamic Contact Angle Measuring System. Contact angles of the probe liquids are the parameters which are then used to calculate the γ of the solid samples. Three probe liquids of known γ were used for the measurements: water, glycerol and diiodomethane. Contact angle was measured using sessile drop method, five times on each sample, on the different control elements on the printing plate. The shape of the probe liquid drops was a spherical cap, and the volume of the drops was 4 μl. All measurements of the contact angles on the samples were performed in the same moment after the drop touched the photopolymer surface (10 s), and the average value was calculated (ASTM International, 2003). After that, mean value of the contact angle for each sample was calculated and γ of printing plates was obtained using the Owens-Wendt-Rabel and Kaeble (OWRK) method, by means of the OCA20 software support (Dataphysics, n.d.). The OWRK method is applicable for the calculation of γ of polymers, aluminium and coatings (Owens and Wendt, 1969).

A Cooper Sheet Fed Flexo Press was used to produce the laboratory test prints by means of the UV-ozoned samples of MacDermid LUX ITP 60 printing plate. The Cooper Sheet Fed Flexo Press is a single colour printing machine for flexography, where the flexographic printing system can be tested throughout the complete print-



a) *b)*

Figure 2: a) Viscosity vs. shear rate of the printing ink, b) viscosity vs. shear stress of the printing ink

ing process with all adjustments in the reproduction steps. Quartz Cationic UV DP1515/1 UltraC plus black from Mirage ink and ceramic anilox roll with cell volume of 2.27 cm^3/m^2, 1049 lpi were used in the printing process. Surface tension of the ink was 33.74 mN/m, with the rheological properties presented in Figure 2.

The pressure during the printing was set manually, following the standard operating procedure for the machine. Cooper press does not enable predefined numerical adjustment of the pressure. Kiss-print is achieved by inserting the printing substrate in the press and lowering the plate cylinder towards the printing substrate until the contact between the plate and the substrate is achieved, but the substrate can still be moved under the plate. Once set, the pressure was fixed throughout the printing process. After adding the printing ink to the ink chamber and wetting the plate with the ink, the first two prints were produced and discarded before producing the three prints that have been used for measurements. Printing speed was 24.17 m/min.

3. Results and discussion

3.1 Surface free energy of MacDermid LUX ITP 60 printing plate

Figure 3 presents the γ changes in total (γ^{total}) and its polar (γ^{p}) and dispersive (γ^{d}) components of UV-ozoned printing plate samples. It is evident that γ^{d} does not change distinctively throughout the variation in UV-ozone treatment. On the other hand, γ^{p} increases progressively from 6.55 mJ/m^2 to 23.13 mJ/m^2, while γ^{total} increases from 43.37 mJ/m^2 for non-treated printing plate sample up to 59.40 mJ/m^2 for the sample treated with the UV-ozone for 5 minutes.

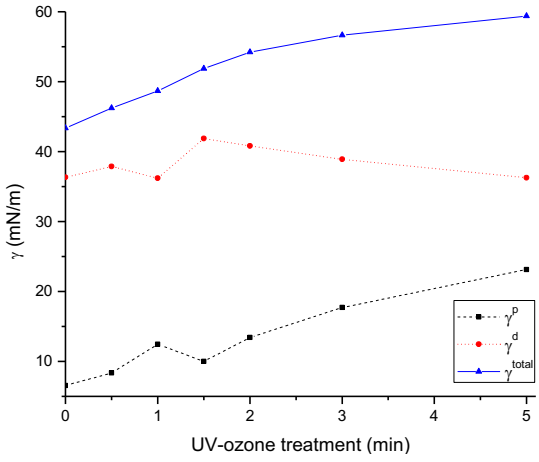


Figure 3: Surface free energy of UV-ozoned LUX ITP 60 printing plate samples

It can be seen that γ^{p} primarily influences the increase of the values of γ^{total}. The reason for this is the integration of the oxygen in the surface layer of the photopolymer material during the UV-ozone treatment, common to the UV treatments in the printing plate processing (Tomašegović, 2016). On the other hand, the decreasing trend of γ^{d} after 1.5 minutes of UV-ozone treatment points to the start of the material degradation, since γ^{d} can be directly related to the crosslinking degree (Tomašegović, 2016).

This means that prolonged UV-ozone treatment can result with shortened lifetime of the printing plate and decreased mechanical and chemical resistivity in the printing process. Therefore, maximal duration of the UV-ozone treatment should be adjusted to the specific photopolymer material and preliminary tests should be performed before the application of the treatment in the real system.

3.2 Test prints

Test prints of the motives transferred to MacDermid LUX ITP 60 printing plate were produced by means of the Cooper press. Several parameters were measured on test prints: width of the fine lines, coverage values of the halftones from 1 % to 100 % and the approximate ink volume in the halftone area. All parameters were measured and monitored in dependence on the duration of UV-ozone treatment.

3.2.1 White light interferometry and analysis of fine lines on test prints

Width of the fine lines on the prints produced by the Cooper press was measured by using a 2-dimensional analysis tool in Vision 32 software. Result of the measurement is displayed in Figure 4.

Figure 4: Cross section and width of the printed fine line measured by white light interferometry

In Figure 5, Δ*d* on *y*-axis presents the difference between width of the line on prints produced without the UV-ozone treatment and the width of the line on the print produced with specific duration of UV-ozone treatment (lines are labeled on the legend by their initial width on the motive without the UV-ozone treatment). The measurement results have shown that the width of the lines reduces with increased duration of UV-ozone treatment.

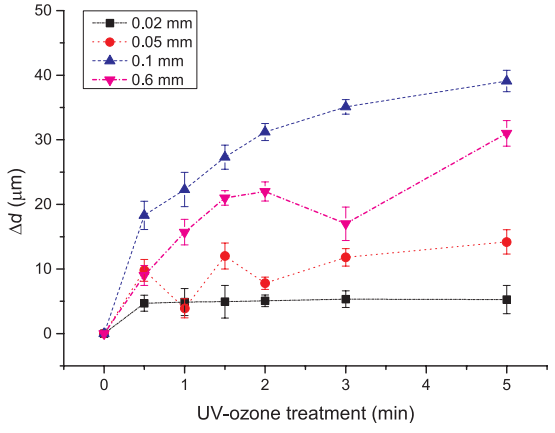


Figure 5: The change of width of the fine lines printed with UV-ozone treated plates

Previous research (Tomašegović, et al., 2016) showed that the UV-ozone treatment increases the hardness of the flexographic printing plate due to further crosslinking in the volume of the material and changes in the chemical bonds in the photopolymer material. Indeed, hardness of the MacDermid LUX ITP 60 printing plate samples was measured using a Shore A hardness tester, and the results showed the increase in hardness of approx. 4 Shore A between the non UV-ozoned sample and the sample UV-ozoned for 5 minutes. Therefore, printing elements on the plate become more mechanically stable and deform less in the printing process. Furthermore, the difference between the prints of the fine lines produced by means of non UV-ozoned and UV-ozoned printing plates amounts up to 35 % of the initial width of the line printed by means of the printing plate without the UV-ozone tretement. Greater mechanical stability would reduce the barreling and stretching mechanisms of halftone dot and track expansion and therefore UV- ozone treatment could be used to optimize printing fine elements in flexography.

Figure 6 presents the common test motive used in applications of various printed electronics. It consisted of the fine lines of different initial widths, which are connected to a "pad". The crucial part considering the quality of the print is the "line-pad" joint. Because of the elastic deformation of the printing plate during the engagement, the shape of either pad or line near the joint can deform. The results are usually either correctly printed line, but poor quality of the connection between the line and pad, or vice versa, which both can result in problems with conductivity when printing conductors and other electronic components.

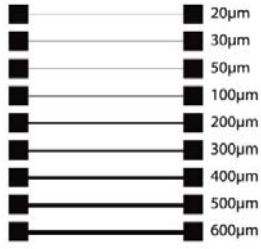
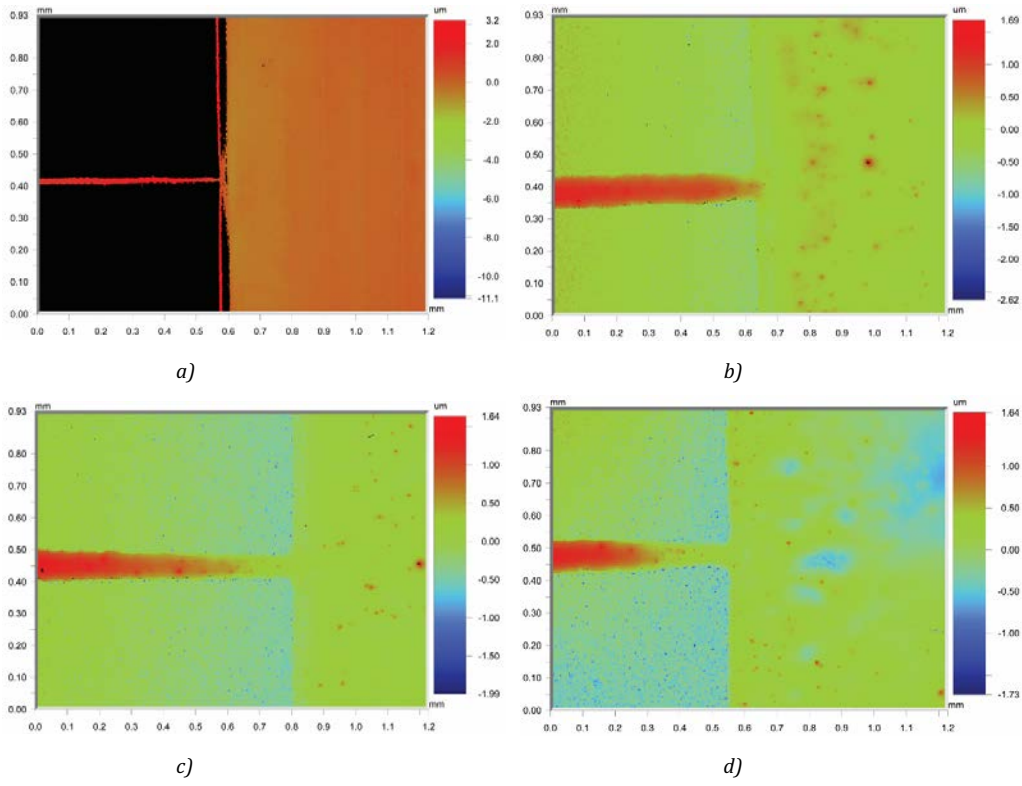


Figure 6: Motive for testing print quality in printed electronics

Figures 7.1–7.4 present the magnified white light interferometry measurements of fine lines connected to the pad on the printing plate and prints.

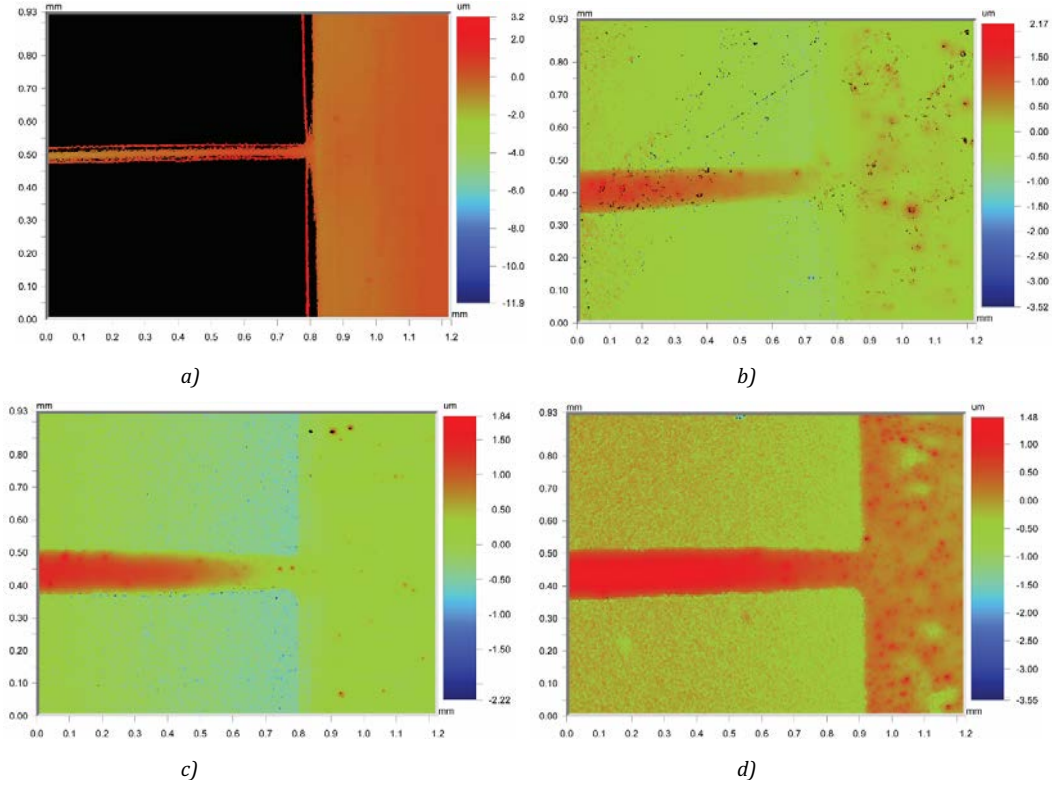
The printed area of the connection of line and pad improves both in the uniformity of the ink layer on the line, and the area of the connection between the elements with prolonged UV-ozone treatment. This is due to the changes in mechanical properties of the printing plate after UV-ozone treatment. As the hardness of the printing plate increases due to increased UV-induced



a) *b)*

c) *d)*

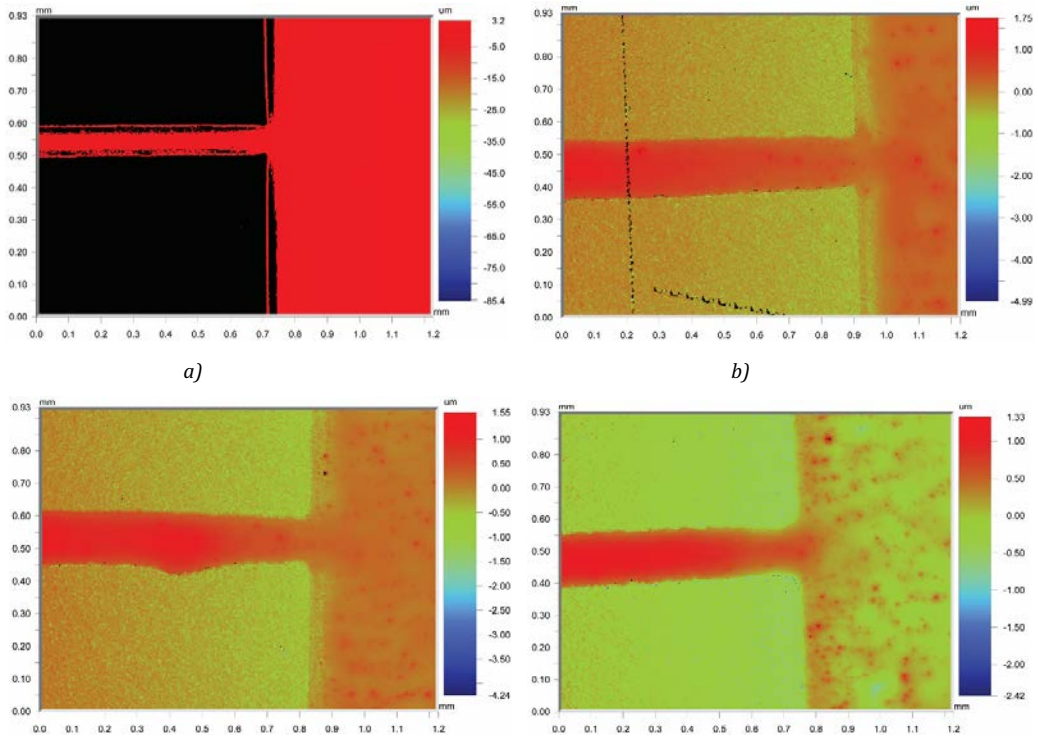
Figure 7.1: 20-µm line and pad joint on: a) printing plate, b) print without UV-ozone treatment of plate, c) print obtained by plate UV-ozoned for 2 minutes, d) print obtained by plate UV-ozoned for 5 minutes



a) *b)*

c) *d)*

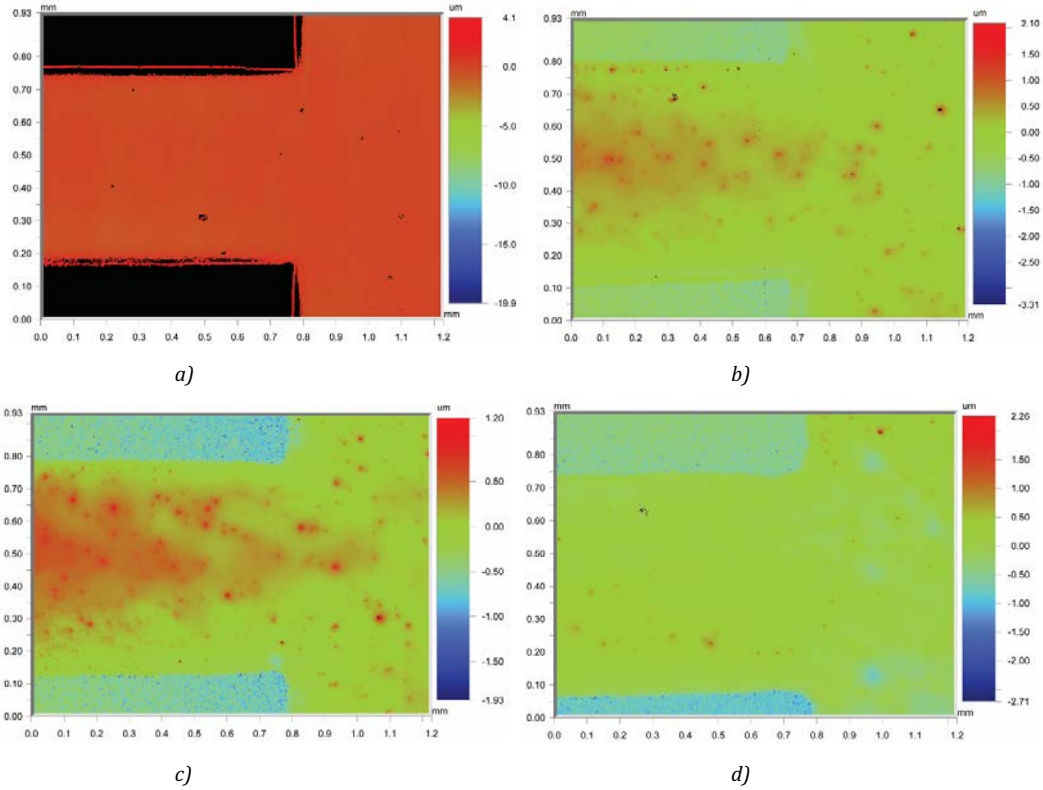
Figure 7.2: 50-µm line and pad joint on: a) printing plate, b) print without UV-ozone treatment of plate, c) print obtained by plate UV-ozoned for 2 minutes, d) print obtained by plate UV-ozoned for 5 minutes



a) *b)*

c) *d)*

Figure 7.3: 100-µm line and pad joint on: a) printing plate, b) print without UV-ozone treatment of plate, c) print obtained by plate UV-ozoned for 2 minutes, d) print obtained by plate UV-ozoned for 5 minutes



a) *b)*

c) *d)*

Figure 7.4: 600-µm line and pad joint on: a) printing plate, b) print without UV-ozone treatment of plate, c) print obtained by plate UV-ozoned for 2 minutes, d) print obtained by plate UV-ozoned for 5 minutes

crosslinking in the volume of the photopolymer, elastic deformation of the printing plate during the printing process decreases. However, UV-ozone treatment should be properly adjusted to obtain both improvement in the print quality and the required thickness of the ink layer, important in printed electronics domain, since previous research showed the decreased thickness of the ink layer on the print due to the increased γ and therefore improved wetting of the ink on the UV-ozoned printing plate samples (Tomašegović, et al., 2016).

3.2.2 Roughness of the solid printed surface

Changes in the R_a and R_z roughness parameters on the solid-tone areas on the prints after the UV-ozone treatment of the printing plates are presented in Figure 8, R_a parameter ranges from 0.037 µm to 0.050 µm, and R_z from 0.35 µm to 0.44 µm.

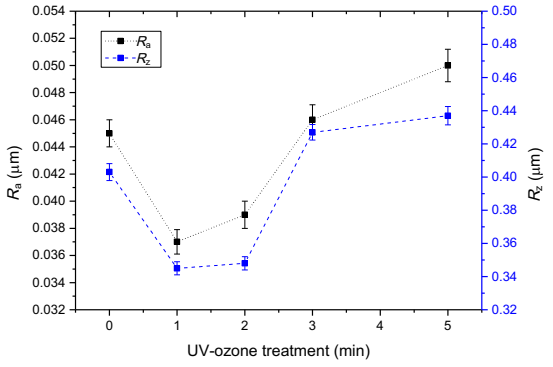


Figure 8: R_a and R_z parameters on solid-tone prints produced by UV-ozone treated plates

The measured changes in the roughness parameters are not as significant quantitatively, but they do point to the changes in the plate–ink interaction because of the UV-ozone treatment. Specifically, as roughness of the printing plate initially increases due to the UV-ozone treatment up to 2 minutes (Tomašegović, et al., 2016), roughness of the printed solid-tone decreases. After 2 minutes of the UV-ozone treatment, roughness of the printing plate samples starts to decrease, resulting with the increased surface roughness of the solid-tone areas of the print. Therefore, it can be concluded that the changes in the roughness of printing plate do not cause the changes in R_a and R_z parameters on the prints, since the trends of the changes are opposite. The effect of the roughness of the printing substrate is also not influencing significantly the roughness of the prints, since its mean R_a parameter equals 0.027 µm, and R_z 0.33 µm.

Therefore, the changes in the roughness parameters of the prints can be connected to:

- peaked γ^d of the printing plate samples and changes in the $\gamma^d - \gamma^p$ ratio between 1 and 2 minutes of the UV-ozone treatment (Figure 3) and apparently to some extent altered interaction between the printing plate and the ink, resulting with the increased homogeneity of the printed layer in this timeframe of the duration of the UV-ozone treatment;
- increased hardness of the printing plate after the prolonged UV-ozone treatment (Tomašegović, 2016) and therefore decreased ability of the printing plate to conform to the substrate when printing. Therefore, the impaired uniformity of the transferred ink layer, in conjunction with its decreased thickness, will result with the decreased smoothness of the printed layer.

3.2.3 Surface coverage of halftones on test prints

The trend of printing ink transfer for the halftone reproduction in dependence on the UV-ozone treatment is presented in Figure 9. Due to changes in the mechanical properties of the photopolymer material caused by UV-ozone treatment, dot gain is less expressed with prolonged duration of the UV-ozone treatment. FlexoSync 56 compensation curve was applied to all samples of printing plates, but due to the features of laboratory printing process, dot gain is higher than expected. Nevertheless, 5 minutes of UV-ozone treatment decreased the coverage from 90 % to 80 %, on the field with 50 % nominal coverage value. Therefore, UV-ozone treatment can be used as a tool for optimizing dot gain; however, the level of treatment must be investigated for different printing inks and substrates.

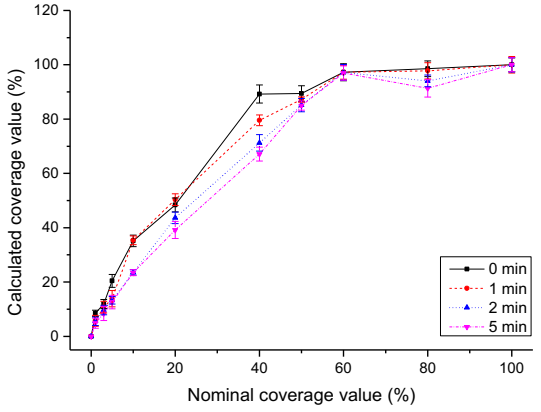


Figure 9: Coverage values of halftones on prints produced by UV-ozone treated plates

3.2.4 Ink layer volume on test prints

In Figure 10 the results of ink volume calculations on the halftone area are presented in µm^3 per area of 1 mm^2. Similar to the results of coverage value calculations, the volume of the ink on the halftone prints decreases with prolonged UV-ozone treatment.

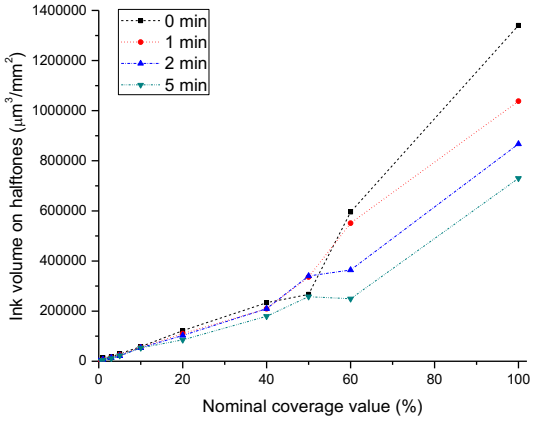


Figure 10: Ink volume on halftones on prints produced with UV-ozone treated plates

The results of the ink volume calculations are in direct relation with previously obtained results of the ink layer thickness on prints produced by means of the UV-ozoned printing plate samples (Tomašegović, et al., 2016). The decreased ink layer thickness both on 100 % coverage value and on halftone areas with prolonged UV-ozone treatment can be used for the fine adjustment of the ink layer features on the print by means of the printing plate, beside the anilox.

Since the cell count and volume on the anilox roller define only the amount of the ink available for the transfer to the printing plate, surface and mechanical properties of the printing plate modified by specific surface treatment can be used to regulate the ink transfer in the "printing plate–substrate" system.

4. Conclusions

The aim of this research was to modify the surface properties of photopolymer flexographic printing plate by means of UV-ozone treatment in order to influence the properties of the print. At the same time the printing plate needed to retain its functional properties.

The tested printing plate displayed a significant increase of γ after 5 minutes of the UV-ozone treatment. The difference in γ^{total} between non-exposed sample and sample exposed to the UV-ozone treatment for 5 minutes was cca 15 mJ/m^2. The main reason for the changes was the increase of γ^{p} due to integration of the oxygen in the composition of the photopolymer material.

The γ^{d} started to increase with shorter exposures to UV-ozone treatment, but decreased after longer exposure. This indicates the start of the degradation of the photopolymer material as a result of longer exposures to the UV-ozone treatment.

The UV-ozone treatment of the printing plates resulted in changes of the width of the fine lines on test prints, roughness of the printed layer, surface coverage of the halftones, and ink volume on test prints. Width of the fine lines decreased after the UV-ozone treatment, which was caused by the increased mechanical stability of the printing elements. This improvement resulted in lower dot gain on the halftones. Roughness of the printed layer displayed the lowest values for prints obtained by the printing plates treated by UV-ozone for a period of 1–2 minutes.

Due to the improved wetting on the printing plate, a thinner layer of the printing ink is transferred to the printing substrate, resulting in decreased ink volume in the halftone area after the prolonged UV-ozone treatment.

This research has proven that the surface treatment of flexographic printing plate, specifically UV-ozone treatment, affects significantly the properties and quality of the print and can be used to purposefully modify the properties of the printing elements, resulting in the improved quality of the specific print, whether conventional or functional.

With each new technology for printing plate production on the market, some qualitative properties of the flexographic prints increase providing new opportunities for the application of flexography in the printing industry. This research targeted some possibilities for further improvement of high-quality flexographic products in existing systems, with the aim of expanding the further potential for application of flexography, specifically in functional printing.

References

Anderson & Vreeland Inc., 2017. *Toyobo Cosmolight CTP Plate*. [online] Available at: <http://andersonvreeland.com/portfolio/digital-cosmolight-water-wash-plates> [Accessed 4 July 2016].

Asahi, 2015. *New concept from Asahi (Pinning-Top)*. [online] Available at: http://www.ctgraphicarts.com/downloads/AsahiTOPtech.pdf [Accessed 4 July 2016].

Asahi Photoproducts, n.d. *AWP water washable flexo plate*. [online] Available at: <http://www.asahi-photoproducts.com/Datasheet/Plates/Eng/AWP_leaflet.pdf> [Accessed 5 July 2016].

Aspler, J.S. and Lepoutre, P., 1991. The transfer and setting of ink on coated paper. *Progress in Organic Coatings*, 19(4), pp. 333–357.

ASTM International, 2003. ASTM D5725-99(2003): *Standard test method for surface wettability and absorbency of sheeted materials using an automated contact angle tester.* West Conshohocken, PA, USA: ASTM International.

Bodwell, R. and Scharfenberger, J., 2011. *Advancing flexography: the technical path forward*. DuPont Packaging Graphics. [pdf] Available at: <http://www2.dupont.com/Packaging_Graphics/en_US/assets/downloads/pdf/AdvFlexo_Brochure.pdf> [Accessed 5 July 2016].

Bollström, R., Tuominen, M., Määttänen, A., Peltonen, J. and Toivakka, M., 2012. Top layer coatability on barrier coatings. *Progress in Organic Coatings*, 73(1), pp. 26–32.

Bollström, R., Tobjörk, D., Dolietis, P., Salminen, P., Preston, J., Österbacka, R. and Toivakka, M., 2013. Printability of functional inks on multilayer curtain coated paper. *Chemical Engineering and Processing: Process Intensification*, 68, pp. 13–20.

Dataphysics, n.d. *OCA 30: Video based, automatic contact angle measuring device*. [online] Available at: <http://www.asi-team.com/asi%20team/dataphysics/DataPhysics%20data/OCA30_E.pdf> [Accessed 22 April 2016].

DFTA, 2006. *DFTA CtP Strip V1.3:Description of evaluation*. DFTA. [pdf] Available at: <ftp://ftp.partners.hu/incoming/kkornel/DFTA_KK_CtP_V13_Evaluation_0605.pdf> [Accessed 5 July 2016].

Esko, 2012. *Flexo plate dot shapes*. [online] Available at: <http://www.fppa.net/events/2012convention/2_round_flat_why_when.pdf> [Accessed 4 July 2016].

Flint Group, n.d. *Nyloflex Sprint Digital*. [online] Available at: <http://www.flintgrp.com/en/documents/Printing-Plates/nyloflex/nyloflex_Sprint_EN.pdf> [Accessed 4 July 2016].

Flint Group Flexographic Products, n.d. *Nyloflex NEXT.* [online] Available at: <http://www.flintgrp.com/en/documents/Printing-Plates/info/nyloflex_NEXT_EN.pdf> [Accessed 5 July 2016].

International Organization for Standardization, 2012. *ISO 12647-6:2012: Graphic technology – Process control for the production of half-tone colour separations, proofs and production prints – Part 6: Flexographic printing*. Geneva: ISO.

Kodak, 2014. *DigiCap NX Patterning*. [pdf] Available at: <http://graphics.kodak.com/KodakGCG/uploadedFiles/DigiCapNX_WhitePaper.pdf> [Accessed 5 July 2016].

MacDermid, 2014. *LUX In-the-plate: Photopolymer*. [online] Available at: <http://printing.macdermid.com/files/5614/2625/6737/LUXITP60_Brochure-1.pdf> [Accessed 4 July 2016].

Mahović Poljaček, S., Cigula, T., Tomašegović, T. and Brajnović, O., 2013. Meeting the quality requirements in flexographic plate making process. *International Circular of Graphic Education and Research, 6*, pp. 62–69.

Mahović Poljaček, S., Tomašegović, T. and Gojo, M., 2012. Influence of UV exposure on the surface and mechanical properties of flexographic printing plate. In: D. Novaković, ed. *GRID 2012: 6th International Symposium on Graphic Engineering and Design*. Novi Sad, 15–16 November 2012. Novi Sad, Serbia: University of Novi Sad. pp. 135–140.

Mahović Poljaček, S., Tomašegović, T., Cigula, T. and Milčić, D., 2014. Application of FTIR in structural analysis of flexographic printing plate. In: *46th Annual International Conference on Graphic Arts and Media Technology, Management and Education*. Athens, 25–29 May 2014. pp. 133–142.

Mahović Poljaček, S., Tomašegović, T., Cigula, T., Donevski, D., Szentgyörgyvölgyi, R. and Jakovljević, S., 2016. Accelerated aging of photopolymeric material used in flexography. *International Journal of Chemical, Molecular, Nuclear, Materials and Metallurgical Engineering,* 10(4), pp. 342–347.

Matsubara, T. and Oda, R., Zeon Corporation, 2013. *Block copolymer composition for flexographic printing plates*, U.S. Pat. 8,578,852 B2.

Mogg, B.T., Claypole, T., Deganello, D. and Phillips, C., 2016. Flexographic printing of ultra-thin semiconductor polymer layers. *Translational Materials Research*, 3(1), p. 015001.

NOVASCAN Technologies, n.d. *User guide: Ultra-Violet/Ozone Probe and Surface Decontamination Series Instruments*. [pdf] Available at: <http://microfluidics.cnsi.ucsb.edu/tools/Novascan%20UVOzone%20cleaner%20user%20guide.pdf> [Accessed 5 July 2016].

Owens, D.K. and Wendt, R.C., 1969. Estimation of the surface free energy of polymers. *Journal of Applied Polymer Science*, 13(8), pp. 1741–1747.

Page Crouch, J., 2005. *Flexography Primer*, 2nd edition, Pittsburgh: PIA/GATF Press.

Phillips, C.O, Govindarajan, S., Hamblyn, S.M., Conlan, R.S., Gethin, D.T. and Claypole, T.C., 2012. Patterning of antibodies using flexographic printing. *Langmuir*, 28(25), pp. 9878–9884.

Tomašegović, T., Mahović Poljaček, S. and Cigula, T., 2013. Surface properties of flexographic printing plates related to UVC post-treatment. *Journal of Print and Media Technology Research*, 2(4), pp. 227–234.

Tomašegović, T., 2016. *Functional Model of Photopolymer Printing Plate Production Process*. Doctoral thesis. University of Zagreb, Faculty of Graphic Arts.

Tomašegović, T., Mahović Poljaček, S. and Leskovac, M., 2016. UVA and UVC modification of photo polymeric surface and application for flexographic deposition of thin coatings. *Journal of Applied Polymer Science,* 133(24), p. 43526.

Tomašegović, T., Beynon, D., Claypole, T. and Mahović Poljaček, S., 2016. Tailoring the properties of deposited thin coating and print features in flexography by application of UV-ozone treatment. *Journal of Coatings Technology and Research,* 13(5), pp. 815–828.

Wyant, J.C., 2002. White light interferometry. In: H.J. Caulfield, ed. Proceedings of SPIE Vol. 4737. Orlando, 01 April 2002. Bellingham, WA, USA: SPIE. pp. 90–107.

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Colour management of tablet devices

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Abstract

As of now, the creation and use of tablet devices in society have been strictly focused on the benefits for commercial use. While other devices such as monitors or cameras are capable of device-specific colour management, tablet devices have been left behind with only manufactured colour adjustments available. This has resulted in a limited use of tablet devices such as the Windows Surface, Apple's iPads and Samsung's Galaxy Tab S, in the professional/printing industry. In particular, the use of these tablets have had limited integration with an already existing and functioning colour management workflow. This study analyzed and identified the colour reproduction capabilities of specific tablet devices so that possible workflow or industry integrations can be established. The study evaluated each device through the creation of an ICC profile using i1Profiler. The profiles were then compared using Macbeth ColorChecker Classic Chart for key colour comparison and IT8.7/4 for colour difference values (ΔE_{00}). Amongst all profiles, general colour gamut was observed using ColorThink Pro software. The outcome of the tests has shown that each device tested thoroughly resulted in an acceptable industry set CIEDE2000 standards with average values below 3. It was also seen that each device is limited by various roadblocks or concerns when looking for future integration into professional industry workflows. Overall, while technically usable, the use of tablet devices in the professional/printing industry depends on the extent to which this industry accepts to integrate these devices in their workflows.

Keywords: colour reproduction, colour differences, colour management workflow, colour gamut

1. Introduction and background

In the commercial setting of electronic displays, it is evident that a difference in colour exists between various brands and specific devices including televisions, cameras, monitors, mobile, and tablets. While some of these devices such as monitors and cameras can undergo device-wide colour management, others including tablet devices are left behind with only manufactured colour adjustments being made available. These adjustments cannot be changed, creating limited control over colour accuracy especially if the purpose of the device requires specific colour management. From an average consumer standpoint, colour management capabilities are not a dire necessity with many being accustomed to middling colour accuracy. With basic technology, consumers are capable of viewing devices that are comparable to the best electronic displays of the past and thus, today's manufacturers do not see the importance of incorporating the feature of expanded colour management inclusion; beyond the standardized sRGB profile traditionally found in tablet devices. From a professionally related standpoint, specifically with regards to the printing industry, tablet colour management is promising for an integration to the practical production workflow – especially with regards to commercial monitors used for average viewing and respectively targeted colour managed monitors. For instance, a recent study shows an increasing interest of some professional stakeholders in the packaging industry to use 3D mockups software on iPad devices as an enhancement tool to their existing proofing workflow (Whyte, et al., 2017). With colour management, these devices would be capable of mediocre comparisons; moreover, they would be capable of colour accuracy for soft proofing, beyond proofing just content.

Display Mate Technologies conducted a set of lab experiments to understand display technologies of various tablet devices (Soneira, 2014; 2015). In these experiments, the analyzed absolute colour accuracy indicators were reference points that were devised from four sub-categories including full colour gamut accuracy, facial skin tone colour accuracy, organic colour accuracy, and blue region (cyan to magenta range) colour accuracy. In light of this, Display Mate Technologies

research was limited to the commercial use of tablet devices, particularly aiming at home photography rather than professional work. As such, identifying and understanding factors brought upon by the printing industry would be beneficial. Additional research was conducted by the University of Novi Sad, with a set of experiments regarding tablet colour management as it relates directly to their use in colour soft proofing or another colour accurate dependent applications (Zorić, 2014). The devices were tested using digital versions of the Macbeth ColorChecker Chart (calibrated TIFF files used on the device) as well as Datacolour's SpyderGallery application, which allowed for colour management calibration. The research evaluated in-application colour management but identified the limitations to using specific device software for viewing rather than expanding hardware capabilities.

While in-application colour management would benefit particular industries, the inability to connect with our devices limits integration with print. With this belief, there resides a need for research and experimentation on various tablet devices to examine existing colour reproduction capabilities of hardware and identify future industry possibilities.

2. Materials and methods

In order to study the colour reproduction capability and identify possible future uses of tablet devices in the printing industry, a set of quality reports were produced for each tablet. The tablet devices employed and tested in this study were the Windows Surface Pro 3, Apple's iPad 2, and Samsung's Galaxy Tab S. Each tablet was measured with a 5-point method (the centre and four corners) using the i1Profiler software to check for validity and consistency. An i1Pro 2 spectrophotometer was used to calibrate and identify an ICC profile based on the centre measurement. Measurement conditions for each device used were: a white point correlated colour temperature (CCT) of D65, a luminance value of 105 ± 3 cd/m^2, a gamma of 2.2 and a contrast ratio based on measured luminance. All these settings were used to best simulate standard device conditions on average brightness.

Prior to testing, each device screen was turned on and left to warm up for about 30 minutes to ensure optimal measurement conditions. The Surface Pro 3 was capable of installing i1Profiler software directly on the device, which is not the case with either iPad or Samsung devices. Therefore, to perform the measurements, additional Duet Display software was used to simulate the iPad as a second monitor for a desktop computer that has installed i1Profiler software. The Samsung device required the use of TeamViewer's remote desktop software both on the tablet and the desktop computer. Each device was then set to view the desktop computer on maximum quality settings, allowing the tablet to be measured while the i1Profiler ran on the desktop monitor. The luminance value chosen for this experiment was based on readable values on the tablet devices and provided greater consistency for measurement comparison.

Profiles were generated based on the largest patch set available in i1Profiler's Display settings. The measurements were then compared to the 24-patch Macbeth ColorChecker Chart and a standard IT8.7/4 target embedded in the i1Profiler software. This was then used to identify and evaluate the colour difference (ΔE_{00}) in CIE $L^*a^*b^*$ colour space. The CIEDE2000 equation was used, as it is an accepted method to quantify colour difference in standards such as ISO 12647 (International Organization for Standardization, 2013). In addition, this equation has been found to better correlate with small differences of colour in a human observer (Habekost, 2013). The colour gamuts of the generated ICC profiles were compared and evaluated using ColorThink Pro 3.0.3 software.

3. Results and discussion

3.1 Colour gamut evaluation

When analyzing the results of this study, two major categories were considered. These included the device-specific colour gamut and general colour reproduction capabilities. Beginning with gamut, Figures 1 to 3 demonstrate the graphs of colour gamut of the tested devices with original CIELAB values of the Macbeth ColorChecker Chart for reference. As seen in Figure 1, the Samsung tablet produced the widest colour gamut volume when compared against the iPad and Surface, which shared similar results.

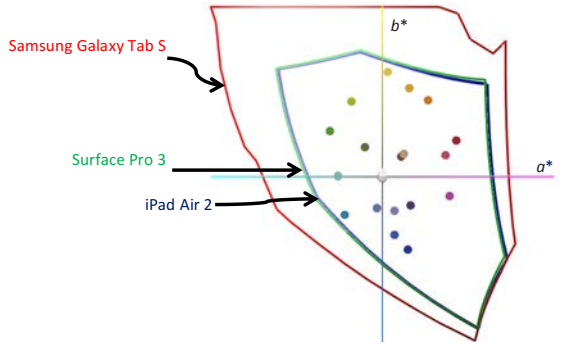

Figure 1: 2D graphs of all device gamuts tested (With original CIELAB values of Macbeth ColorChecker Chart for reference)

When examining and comparing each device gamut, as demonstrated in Figure 2, it was seen that the Apple-based device was capable of achieving slightly more colours within the red to the violet range of the CIE colour space. This outcome could be attributed to the manufactured screen characteristics, which aim for a warmer white point; thus allowing for more vibrant colours. This is done for commercial photo viewing purposes. The Surface Pro produced a gamut with an extended blue to green range. The Surface Pro is aimed towards traditional desktop computer use (word documents, web browsing) and as such has limited manufactured screen adjustments for colour. In general, both devices share similar results when tested under consistent methods.

The Samsung Galaxy Tab S far exceeded the gamut of the iPad and Surface. Samsung was the only device capable of changing its viewing settings based on use. For this test, the default setting was used which primarily focused on vibrant photo viewing. It should be noted that the Samsung's gamut carries some irregularities with regards to the red region and overall uniformity. This is most likely a result of the TeamViewer testing method implemented.

In addition to device-specific gamut, it can also be seen that almost all colours tested using the Macbeth ColorChecker Chart sat within gamut, allowing for accurate colour reproduction measurements of key gamut areas. For the iPad and Surface, the cyan patch sat outside gamut as illustrated in Figure 3. Reproduction of cyan colour is traditionally an issue with LCD technology. Ultimately, by examining colour gamut, it was possible to identify how the hardware and internal colour management of each device influenced its capability to display a range of colour. Notably, it determined how the white point of each device affected a further function for colour management purposes.

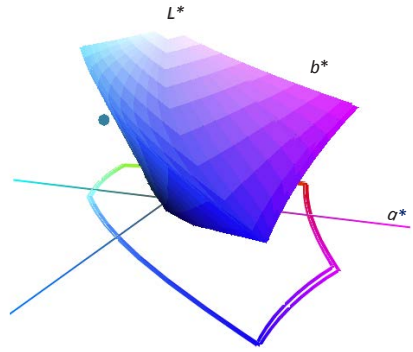

Figure 3: 3D graphs of out-of-gamut cyan colour for iPad and Surface Pro

3.2 Colour reproduction capabilities

Table 1 summarizes the ΔE_{00} comparison between the tested tablet devices and the IT8.7/4 target based on a GRACoL 2006 Coated 1 Reference (NPES, 2007). The average ΔE_{00} values were 1.22 for Surface Pro 3, 2.75 for iPad 2 and 2.81 for Samsung Galaxy Tab S. A significant difference can be seen as the Surface Pro showed the smallest gamut volume, but ultimately achieved better colour reproduction capabilities. This is associated with the Surface Pro's ability to incorporate ICC profiles in oreder to improve or alter manufactured colour reproduction. This proficiency is unachievable using the Apple-based or this particular Samsung device. A significant statistic identified was that for all devices, 90 % values measured resulted in a ΔE_{00} of less than 3. From this, it can be expected that regardless of device, it is possible to achieve a colour difference that is not significantly noticeable to the human eye. In addition, industry soft proofing tolerances would consider these results acceptable (IDEAlliance, 2009). With this in mind, it was also made apparent that for the remaining 10 % colour patches the average ΔE_{00} measured for all devices would be considered noticeable, and does fall under the maximum toler-

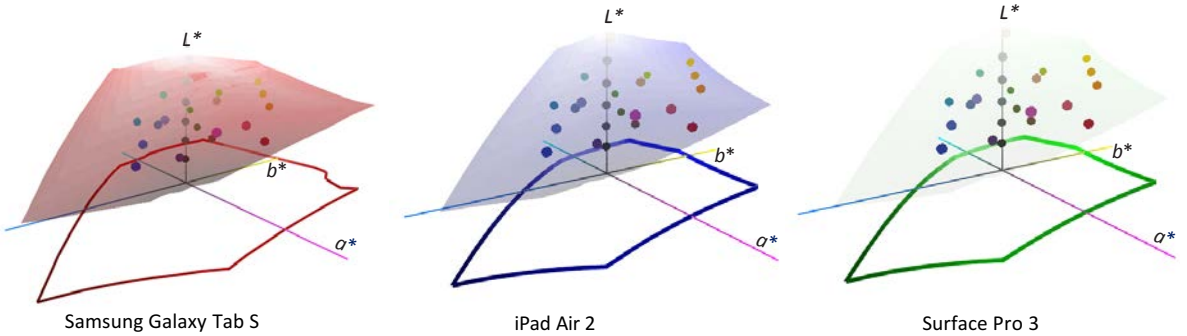

Figure 2: 3D graphs of individual device gamut tested
(With original CIELAB values of Macbeth ColorChecker Chart for reference)

Table 1: Summary of ΔE_{00} comparison for tested tablet devices

	Average ΔE_{00}	Average of lowest 90 % ΔE_{00}	Average of highest 10 % ΔE_{00}	Max. ΔE_{00}
Surface Pro 3	1.22	0.84	4.60	8.15
iPad Air 2	2.75	2.34	6.36	10.51
Galaxy Tab S	2.81	2.35	7.02	12.57

ance expected for soft proofing. While the soft proofing tolerances do not necessarily match the tablet device conditions, it does provide a strong baseline for comparison.

When further examining the maximum ΔE_{00} measured, it was determined that for the LCD devices (iPad and Surface) the cyan patch was culpable. From analyzing each device gamut, it can be recognized that the cyan patch falls outside the available gamut. For the OLED display (Samsung), the white patches were the cause for the colour differences. Based on the examined gamut and general device capabilities, the Samsung device accommodates greatly for its intended viewing condition through internal colour management settings, shifting the CCT white point purely for viewing purposes.

3.3 Tablet's technology considerations

It is evident that manufactured colour accuracy and external colour management on tablet devices will improve in the future, but this is dependent on various impacting factors that need to be considered both in the hardware and software. The screens available today that are used in various tablet devices are targeted for commercial and practical consumer use, which do not meet standard lighting conditions used in the printing industry. Commercial devices traditionally target and use the sRGB colour space by using a white point close to D65. The purpose relies on the profile's broad use across digital media. Steps are also taken to adjust internal profiles to accommodate for commercial viewing as seen on the Samsung device. For each device tested, the CCT exceed 7 000 K at full brightness to better suit consumer activities. The use of higher CCT values of 7 000 K and above results in bluer screens, thus producing inaccurate colour, regardless of the ΔE_{00} measured (Monoyios, 2012); further reason to create consistency by using a controlled luminance value. This could also be looked upon by examining possible subjective tendency with relation to viewing device choice. This could ultimately alter image/photo choice despite the specific devices colour accuracy.

It is indisputable that as screen technologies such as LED, OLED, and LCD continue to advance, colour accuracy and reproduction will improve; particularly seen for the Samsung's OLED display. This, however, can only go so far with regards to colour management for industry applications. Due to this, the need for colour adjustment capabilities within the devices operating system is vital in allowing colour accuracy to spread across the entire device. As of now colour management is only available on tablet devices through specific software applications, which allows viewing images with accurate colours only through these applications. An example of such applications includes the previously mentioned SpyderGallery and X-Rite's ColorTRUE applications. While applications such as these do allow for the illusion of available colour soft proofing options, the main purpose and fundamental reason for colour management is to provide accurate

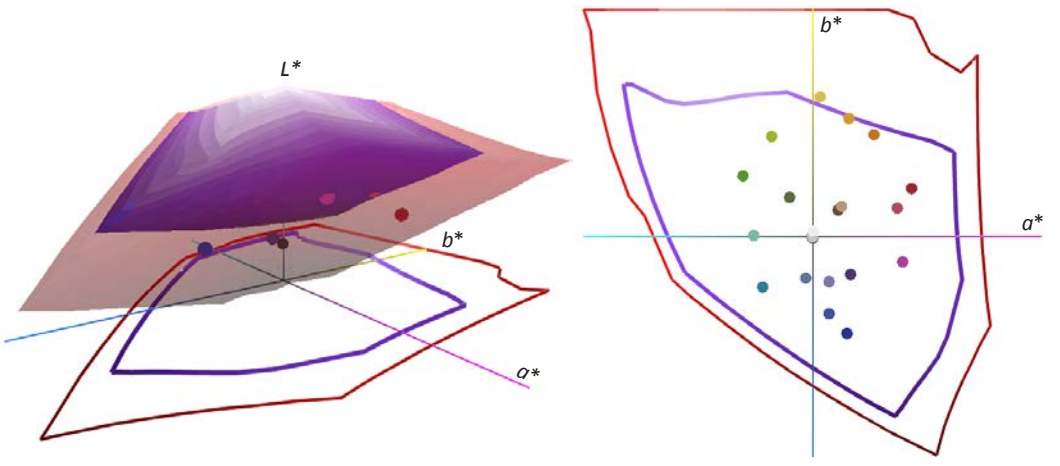

Figure 4: Graphs of Samsung Galaxy Tab S measurement inconsistency

colour display across numerous devices such as cameras, monitors, proofers, and printers.

That being said, most general image viewing applications do not incorporate extensive colour managed settings. The inability to inject and extract ICC colour profiles from individual devices leads to a limited connection to the overall colour workflow. Furthermore, manufactured alternations to typically included colour profiles such as sRGB discourage standardization across devices. Those of which are capable will ultimately be limited by the screen technology used. A comparison of this capability was seen in the Surface Pro 3 as it runs a Windows OS and can make use of the ICC workflow. Overall, the devices tested show a capability of reproducing colour to a standard fitting of the printing industry, particularly the Surface tablet.

In light of this, numerous hardware and software roadblocks limit the functionality of tablet devices for conventional purposes within a workflow. This was particularly seen during the testing process for the Samsung Galaxy Tab S. Due to complications in the Samsung's measurement availability and method, the ICC colour profile and ΔE_{00} colour differences results represented extremely obscure and inconsistent data from measurement to measurement, seen in Figure 4. It was necessary to lower the brightness of the device in order to maintain black detail on the device that is otherwise lost at maximum brightness, though this did not entirely solve the issue. As such, while the Samsung's results prove fruitful for the device gamut in the experiment, performing regular measurements on the device would be considered cumbersome.

4. Conclusions

For the experiment, it can be concluded that tablet devices have yet to become a simple solution or possibility for soft proofing. Out of all devices examined, the Surface Pro 3 was the most promising, as it basically is a mobile computer. The other devices required troublesome testing method or provided inconsistent results that would prove problematic when used for frequent client viewings. In general, a streamlined method of consistency, calibration, and characterization for tablet colour management is necessary before becoming a convenient soft proofing or viewing tool within the print industry.

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References

Habekost, M., 2013. Which color differencing equation should be used? *International Circular of Graphic Education and Research*, 6, pp. 20–32.

IDEAlliance, 2009. *IDEAlliance Proofing Certification Program: Version 19h*. [pdf] IDEAlliance. Available at: <http://files.idealliance.org/certifications/cert_docs_2010/idealliance_proofing_cert_19h.pdf> [Accessed 7 June 2017], pp. 6–8.

International Organization for Standardization, 2013. *ISO 12647-2:2013 Graphic technology – Process control for the production of half-tone colour separations, proof and production prints – Part 2: Offset lithographic processes*. Geneva: ISO.

Monoyios, K., 2012. Gamma and white point explained: how to calibrate your monitor. *Scientific American*. [online] Available at: <https://blogs.scientificamerican.com/symbiartic/how-to-calibrate-your-monitor/> [Accessed 30 May 2016].

NPES, 2007. *Characterization Data Sets: CGATS TR 006*. [online] Available at: <http://www.npes.org/programs/standardsworkroom/toolsbestpractices/characterizationdatasets.aspx> [Accessed 30 May 2016].

Soneira, R.M., 2014. Surface Pro display technology shoot-out: Microsoft Surface Pro 3. *DisplayMate*. [online] Available at: <http://www.displaymate.com/Surface_Pro_ShootOut_1.htm> [Accessed 30 May 2016].

Soneira, R.M., 2015. iPad 2015 display technology shoot-out: iPad mini4 and iPad Air 2 and iPad Pro. *DisplayMate*. [online] Available at: <http://www.displaymate.com/iPad_2015_ShootOut_1.htm> [Accessed 30 May 2016].

Whyte, A., Lumby, N. and El Asaleh, R., 2017. Investigating opportunities for 3D digital package prototypes in the proofing workflow. *Advances in Printing and Media Technology: Proceedings of the 44th International Research Conference of iarigai, Fribourg*. (Accepted for publication June 2017).

Zorić, V. and Karlović, I., 2014. Colour reproduction on tablet devices. *Acta Graphica*, 25(1–2), pp. 31–36.

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Technologies for using Big Data in the paper and printing industry

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Abstract

The paper gives a review about the possibilities of using Big Data technologies in the print industry. Current situation and research are presented with a brief overview and description of the data mining process. Process parameters readouts and process modelling by using problem-solving methods open up new possibilities for production efficiency. Different authors have provided solutions for print and print quality related problems by data collection through sensor readouts and real-time monitoring of different production system variables. Major production techniques (offset and flexo printing) have been partly investigated and monitored through closed inline controls, or metadata communication with the use of Job Definition Format. The researchers have found possibilities in solving particular print or production related issues with the use of Big Data techniques or its subsets, but still, no integrated market ready solution exists. A theoretical framework for a corrugated production factory is shortly presented, outlining possible applications and connections for a fully integrated data mining system that could bring the Industry 4.0 in the printing sector.

Keywords: data mining, process control, printing, papermaking

1. Introduction

The use of Big Data for different applications from marketing, sales, production optimisation and maintenance is offering promises of so-called Industry 4.0, which relies on connected devices, large choice of versatile sensors and intelligent systems. Automation and data exchange of network devices controlled by artificial intelligence systems combined with data handling using cloud computing is expected to increase the productivity and value added part of the production by several percent. The EU has established a rather high goal of 20 % for the ratio of added value of production. The paper and graphic arts companies as a service-based business and in some applications as printed electronics producers are also prone to adapt to the changing business landscape which is emerging. On the basis of a PwC (2016) industry survey, the forest, paper and similar industries are currently automated around 38 % with predicted rise to 72 % in the next five years. The paper and printing industries are under pressure due to decreasing consumption of all paper grades, with packaging papers excluded, by a report made by CEPI (2017) which demands the change of technology to short run production, production optimisation or innovation into new products. As new technology and innovation are quite expensive for small and middle-sized printers, one of the viable solutions is to try to optimise print production processes. Besides Lean Manufacturing and other management tools available for decades, now it is possible to use "redressed" problem solving and analytical tools from the Big Data portfolio for all optimisation, decision-making and problem-solving challenges. Some of the steps in the data mining process are very similar to Root Cause Analysis (management tool for finding hidden or underlying causes for a problem by mapping causing issues), in combination of "5 Why" (repetitive interrogative questioning why has something went wrong, with the goal of finding cause effect relationship in a process) and Failure Mode, Effects, and Criticality Analysis used in classic business problem solving (George, et al., 2005), but contemporary data analytics provide more powerful resources due to increased speed of computing, sensors and networking solutions. The difference between classic business intelligence (reporting) and predictive business analytics is presented in Figure 1.

While the classic problem-solving methods already mentioned have some business value, their complexity is low and are mainly focused on solving one problem or a particular challenge in a total quality management system.

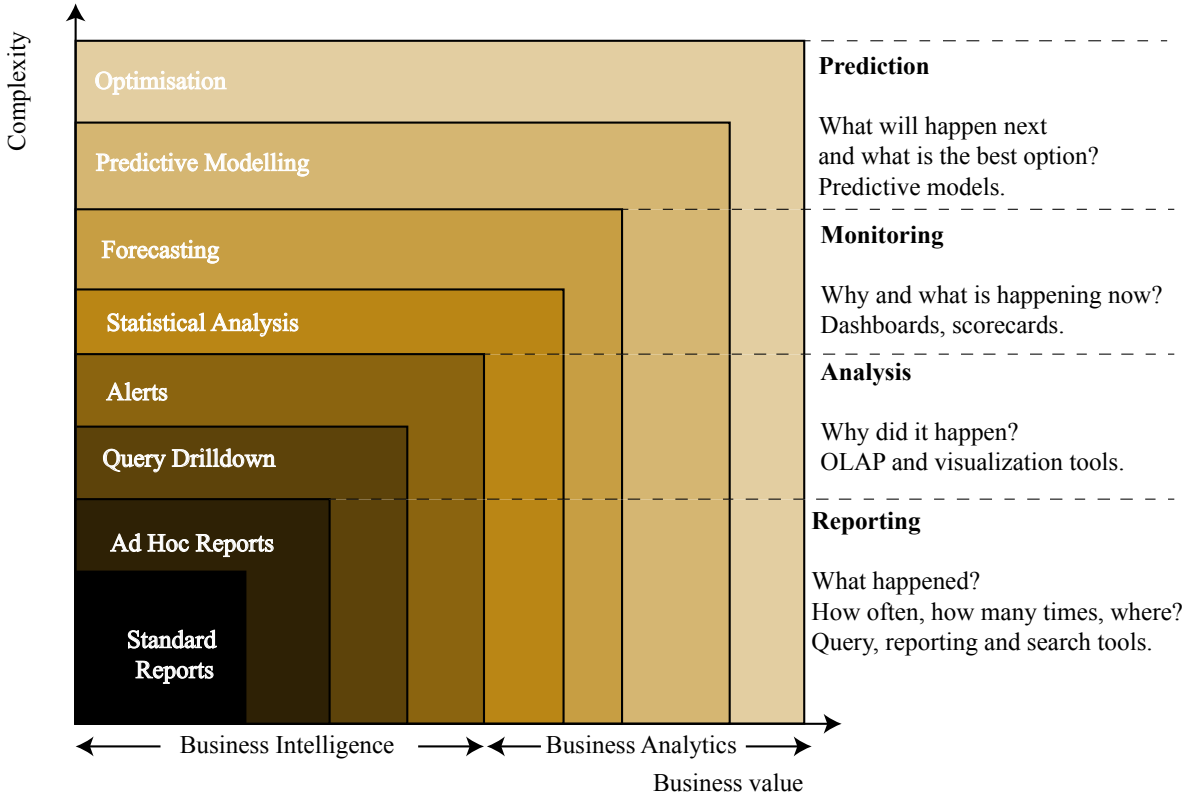


Figure 1: Difference between conventional and predictive analytics value and complexity, adapted from Practicanalytics (2011)

Some of these methods are reactive, while the predictive analytics are driven by more complex methods and software solutions with the aim of maximising business value for a whole company. On the other hand, business intelligence is more concerned with the business side of the company. Business intelligence looks for trends at the macro or aggregated levels of the business, and then drills up, down, or across the data to identify areas of under- and over-performance, while predictive analytics is about finding and quantifying hidden patterns in the data using complex mathematical models that can be used to predict future outcomes (Schmarzo, 2014).

Big Data is a blanket term for any collection of data sets so large or complex that it becomes difficult to process them using traditional data management techniques such as, for example, the relational database management systems (RDBMS). Data science and Big Data evolved from statistics and traditional data management but now are considered to be distinct disciplines (Cielen, Meyman and Ali, 2016). The relationship and the interconnection of different technologies can be observed from Figure 2.

One of the first attempts was the CRoss-Industry Standard Process for Data Mining (CRISP-DM) where the process consists of six steps or phases, as illustrated in Figure 3 (Bijlani and Bauer, 2016).

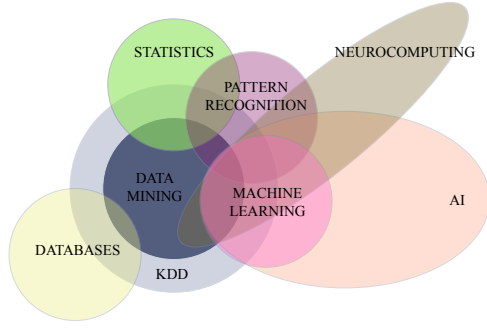


Figure 2: Universe of data science, adapted from Srivastava (2015)

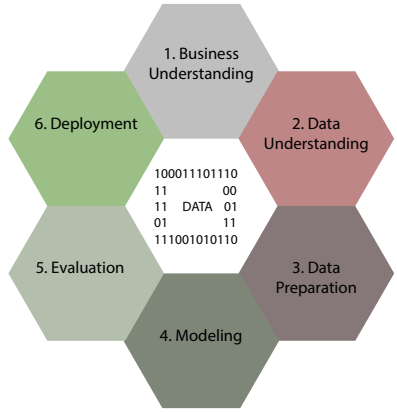


Figure 3: CRISP-DM Conceptual Model, adapted from Bijlani and Brauer (2016)

Data mining as a core of Big Data applies statistical and logical methods to large data sets. These methods can be used to categorise the data, or they can be used to create predictive models. Predictive models, however, transform these descriptions into expectations upon which we can base decisions. For example, the owner of a book-selling web site could project how frequently she may need to restock her supply of a given title, or the supply chain manager of the print house can order paper stock on the basis of previous data (from book seller). It is important to recognise that data mining cannot provide answers to every question, nor can we expect that predictive models will always yield results which will, in fact, turn out to be the reality. Data mining is limited to the data that has been collected (Bijlani and Bauer, 2016). An overview of potential problems and challenges as well as different applications can be found in Hassani and Silva (2015). Data and analytics can mainly be grouped into descriptive, predictive and prescriptive. A large share of the production and business analytics data are descriptive statistics which summarise what has happened during a process or an event. Predictive analytics, on the other hand, uses a vast array of data mining, machine learning and statistics and different modelling to analyse data and to enable some sort of predictions. These predictions are not deterministic as it will happen but probabilistic and will show what may happen. In most cases, the models predict missing numerical data on the basis of previously collected available data. For example, in a standardised printing production, if there was some minor failing out of data causing missing values, these models can predict what was the value or can predict what will be most probably the data, for example ink density or CIE *L*a*b** value of the prints. One of the modifications of predictive analytics is the prescriptive analytics which adds another layer to the data handling the actionable data and the feedback which returns the results of the processed action. Its feature is a prediction of the possible consequences from different scenarios and these models can recommend the best option for a preselected results or expected outcome.

2. Literature overview

One of the early cases of using top down induction of decision tree modelling to reduce cylinder banding in printing was carried out at RR Donelley & Sons Company by Evans and Fisher (1994) in the early 90's where they managed to reduce bands in gravure printing from 538 in 1989 to 42 in 1993. This is a rare case of published data analytics regarding some new data presented and gathered by Hornbuckle (2016). The fact is that on average a commercial printer/press is only productive (generating revenue) 60 % of the time according to a study done by SpencerLab (2017). The typical work cycle of a printing press is presented in Figure 4.

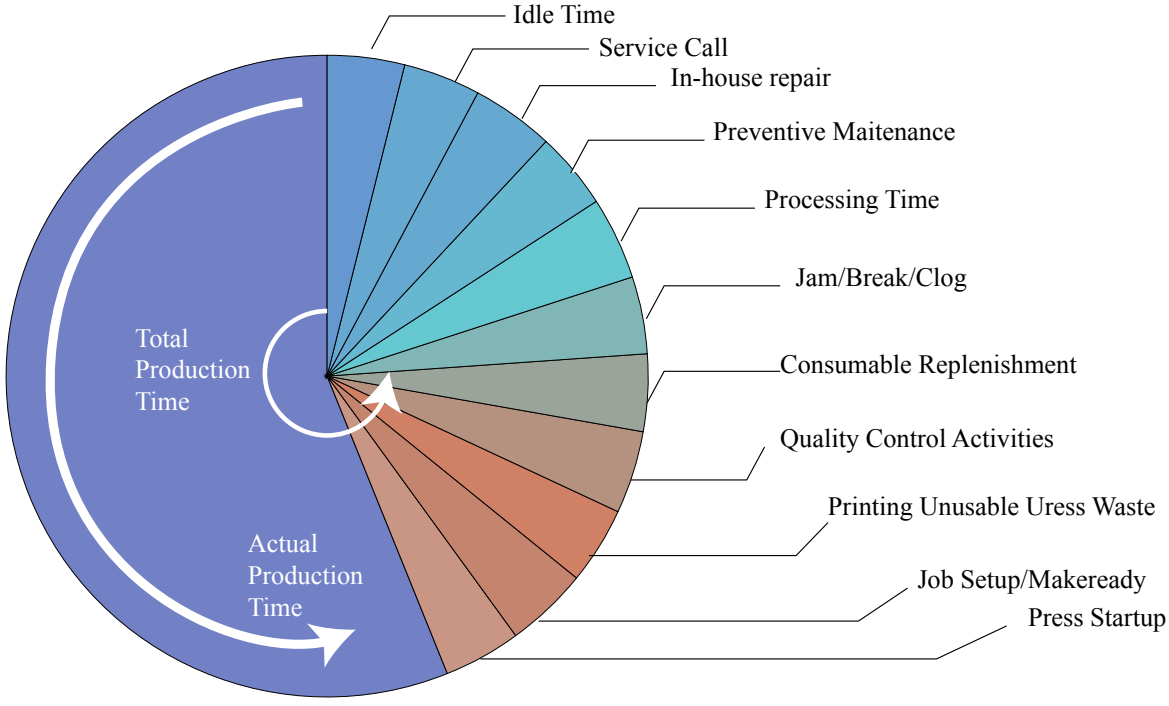


Figure 4: The work cycle of typical press, adapted from SpencerLab (2017)

In their study, they claim that based on their analysis of offset presses from manufacturers including, but not limited to, Komori, Heidelberg, Ryobi, Manroland, Goss and others, the improvement in revenue opportunity ranges from $ 500 000 to worth of $ 9 000 000 per device per year. The variation in additional revenue opportunity has to do with the type of press, its capacity and its duty cycle. From Figure 4, it can be noted that predictive analytics can help with maintenance scheduling and optimisation and also spare parts inventory or additional support materials which can lead to savings in ordering and warehousing. In the papermaking, some of the tools for production optimisation were published by Linnala and Hämäläinen (2001) who described the application of bi-level dynamic multi objective optimisation to the papermaking process, or more accurately, the paper web brake system. The results show that the approach was successful: capital costs were decreased while maintaining adequate process stability. However, the computing time requirements were relatively high; to reduce them, the operational optimisation on the lower level could be performed using a slightly simplified process model. A similar subject was examined in a paper by Hämäläinen, Madetoja and Ruotsalainen (2010). In paper industry one of the recent approaches was published by Fu and Hart (2016) where the authors collaborated with MWV mill which battled with significant quantities of internal rejects and production downtimes. The authors, due to the failure of the classic problem-solving methods to tackle the issues, deployed Big Data analysis to determine the root causes. They reported that 6 000 operating variables were selected with more than nine billion data points in the period of almost three years. The results indicated an action which changed process targets and technological change in the process of drying. In a paper by Jackson (2011), the author presents case studies involving Big Data techniques for value chain cost and return of investment (ROI) optimisation in the papermaking industry.

There were also studies trying to solve overall quality and printability issues like in a thesis work by Gerard Leloup (2002), where the author tries to integrate the quality factors and predicted values for flexography through the use of "Printability Coefficient". The author used quality factors (mottling index, edge sharpness, dot gain, density, dot deformation) with different contribution importance to calculate the final p coefficient value.

The calculation was done for the total variation range of the different parameters and then reduced to a "united result" in percentage. With the two precedent results and the definition of units (c_i), it was also possible to calculate first the partial and then the global influence, in a percentage of "P units", of each primary parameter onto the final "Printability Coefficient". The result of the calculation is called unit influence coefficient (f_i). The calculation of the distance of the user's values (x_i) to the references values (a_i) will then be the first step of the calculation procedure. The obtained values will be divided by the defined units (c_i) and then multiplied by (f_i). The sum on the index "i" is called p, which is presented in Equation 1:

$$p = \Sigma\{[(x_i \cdot a_i)/c_i] \cdot f_i\} \quad [1]$$

Also, the same study claims that is a good visual correlation with the human observers assessment and the final conclusion is that there is a possibility that this method can be used in the printing industry. In another thesis by Lundström (2014) he used image analysis and machine learning methods to model offset printing. The author tried to solve problems of the data mining and modelling through the use of three levels of situation awareness. On the basis of chosen print quality parameters, the author used Random Forrest method of machine learning for training for a model so that the observed quality scores give a set of computed print quality attributes. He concluded that results obtained in the thesis strongly indicate that the computational intelligence-based approach can provide an objective print quality assessment. Whilst other researchers focus on a global approach where a large area of the print is scanned, the techniques developed in this thesis are able to compute useful print quality attributes from small test areas. It was demonstrated that the overall print quality scores obtained from human assessed print samples can be modelled with a good accuracy by using the print quality attributes acquired on-line from the printing press. In their study, Parola, et al. (2003) developed a software in MATLAB and used it in the web print measurement. They have tested their system on a newspaper press concentrating on paper web tension problems while investigating more than 2 000 customer reels. They have reported that the press components had major influences on the slackening of the web. Beside press parameters, there were correlations regarding paper properties which influenced press register accuracy. The end-user printer found the IQTension named software measurement module useful for troubleshooting and material evaluation. Similar problems regarding web printing were studied by Alzghoul, et al. (2009) where they used data mining techniques with two approaches to study web breaks. They used genetic search to analyse process results with a set of input variables providing the lowest average loss incurred in taking decisions. They have reported on average 93.7 % of test data set were classified correctly. Also, there were some statistical studies in flexo by Matulaitienė and Jurkonis (2013) in analysing a one year run of flexo press and mistakes using SPSS statistical software. One more study in flexo printing problem-solving data mining was carried out by Ejsmont, Krystosiak and Lipiak (2015). One large

study regarding banding in gravure printing was presented by Gaudard, Ramsey and Stephens (2006), where they used JMP software for data analysis and data mining techniques on an available data set regarding banding problems. They found that banding has 11 categorical variables and 18 continuous variables in predictors. They have used both partition examples and classification trees as a subpart of Six Sigma project work.

3. Integrating the data collection

The paper production machines have a high degree of automation. Preventive maintenance of sensors/scanners and actuators in the machine level control system (MCS), process control system (PCS) and quality control system (QCS) are key enablers for achieving continuous availability of the sensors/scanners over the entire life cycle of the system. In addition, automatic controllers have to be constantly adapted to the altered conditions and goals of paper production and this closed production circle is enabled through proprietary software. Logs and sensors reading regarding different production parameters are implemented to wet end, dry end, and stock preparation process phases. In a paper by Gough, et al. (2007), the authors present a model-based predictive adaptive process controller on a number of challenging pulp and paper mill control loops including paper machine reel brightness control, lime kiln temperature profile control, slaker temperature control, and extraction stage pH control. The presented solution resulted in financial cost saving and enables paper makers to significantly improve their process control. Also, some mathematical modelling of pulp and paper production is presented in a work by Jansson, et al. (2004). One of the largest company in the paper sector, Voith, uses complex process and predictive analytics in the PaperMiner software for process optimisation where 6 000 readings are continuously taken and stored during the paper production. The PaperMiner and the process control software relies on self-organizing maps (SOM) (Bullinaria, 2004). The SOM method can be used for forecasts with good success. Once a SOM has been generated, the place of a modified machine setting can be determined on the two-dimensional map, and it can be used to determine the expected values for the desired target parameters, such as porosity, formation, etc. (Bamberger and Nicolas, 2005). Of course, the quality of such forecasts is greatly dependent on the number of data sets used to generate the map, and whether or not all major influences were included. Decision Trees are another method of analysis. In order to use Decision Trees, a target value to be analysed is first selected. The Decision Tree can then be used to find out which process adjustments must be made. Another product is OnV, which is predicting quality parameters based on readings from process data – in real time. As an example of sensor complexity in a sensoring system on a wet end of a paper making machine by Voith, necessary for good data array access for prediction purposes, is shown in Figure 5.

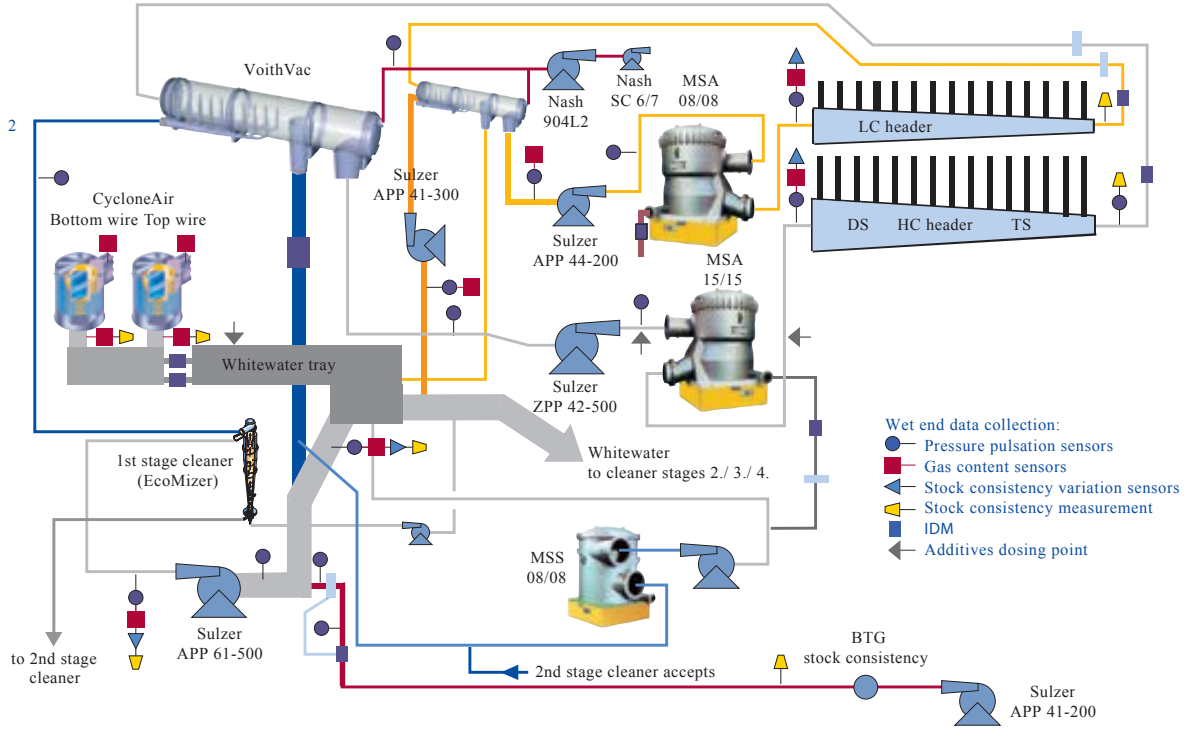


Figure 5: One of the industrial solution of sensor readings for process control by Voith, adapted from Stibl and Natterer (2005)

On the other hand, the printing and graphics arts industry is lagging in terms of integrated process automation and solutions for predictive analytics. There are several closed loop control systems for web printing with modelling and analytics (Kaestner and Nilsson, 2003; Verikas, Malmqvist and Bergman, 2000; Shankar, Ravi and Zhong, 2009) or Heidelberg's Prinect Image Control but authors report several problems of these systems (focusing just on the colour aspect of the printing reproduction):

- Uncertainty in both printing and papermaking industries about the main reasons causing too extensive variations of high-quality colour prints leading to insufficient overall print quality, customers' complains, and substantial economic losses.
- Lack of comprehensive knowledge of the interaction between paper, printing press, ink, and other constitutes of the printing process. This gap leads to difficulties in finding economically plausible means of adjusting technological parameters for optimising the papermaking and printing processes.
- Lack of robust tools for print quality predictions based on various paper, ink, printing press and process parameters.
- Lack of tools capable of online measuring of several print quality attributes, which aggregated into a print quality measurement provide print quality assessments well correlating with human evaluations.
- Lack of tools capable of explaining which technological process parameters are failing when the overall print quality is insufficient.

In a broader view, the printing industry has recently started to implement the Management Information Systems (MIS) which are large pieces of software covering from Customer Relationship Management (CRM), to scheduling and estimating of print, with more or less basic tools for process control and capabilities. One of the interface solutions, which enables the communication between different machines and computers, is the one based on Job Definition Format (JDF). This format allows systems from many different vendors to interoperate in automated and MIS centric workflows. Currently, this system is still developing and it is not a straightforward one (the papermakers have closed loop as the installations are mainly from one producer), because of a large number of equipment and software producers. There is a possibility to make a relational database through the JDF Storage Engine which can create some sort of base for the Data Mining and Analytics but there are no reports about a larger scale of industry implementation using this capability. The previously mentioned Prinect Image Control by Heidelberg is scanning the printed sheet and the reference print control strips and makes end loop quality control adjustment based on a preset data either by internal database or by JDF file. But it still lacks the sensoring of all process parameters (paper condition, ink viscosity and temperature, print pressure) and prediction of colour on the basis of these readings. As we can observe in Figure 6,

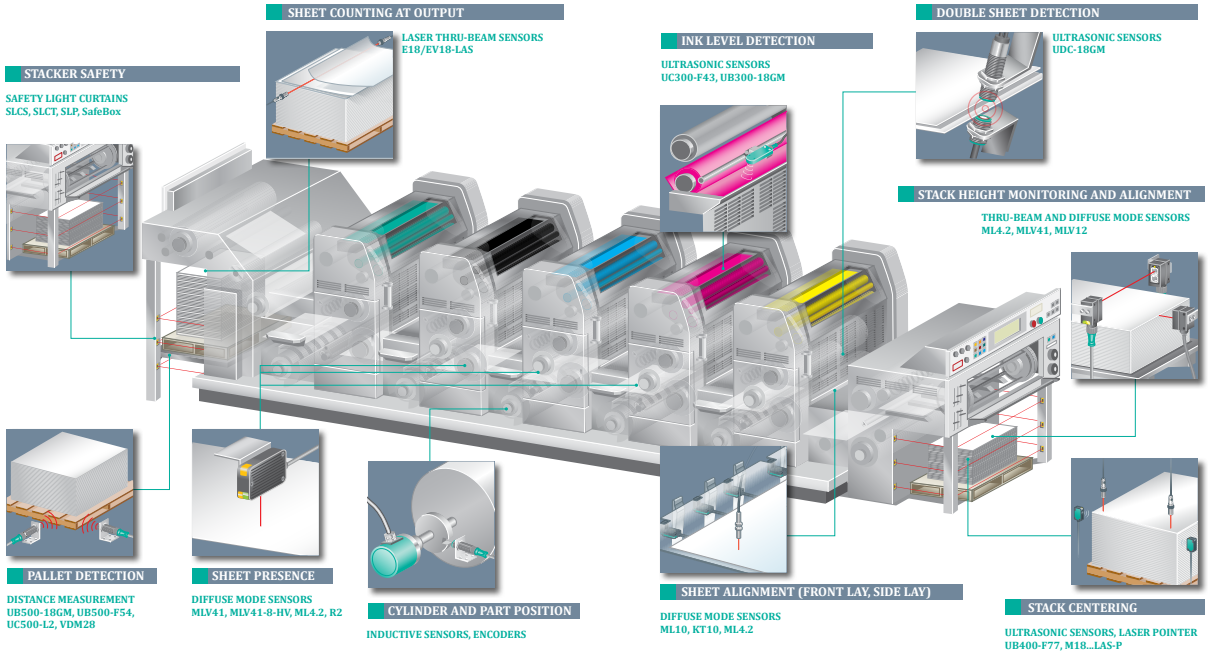


Figure 6: Sensor systems by Pepperl+Fuchs Inc. (2003) for sheet-fed offset printing press

a solution for an array of sensors for the sheet-fed offset printing press enables a lot of readings, but there is a lack of many sensors for process control and data gathering for process variables which can influence the final print quality.

The MIS software solutions or production control software enable business analytics about production speed, downtimes (where the causes are often manually put in by the operator) and can serve to improve efficiency regarding printing press operation and capacity handling. The joining of the two process control systems into one Big Data capable system is still a work in progress for the printing industry.

4. Theoretical blueprint for a corrugated factory

To show the possibilities of using Big Data and data analytics in the printing industry, the theoretical blueprint of a corrugated factory with data collection points is presented. One of the challenges is solving the "5 V" of Big Data (Volume, Velocity, Variety, Veracity and Value). In a book by Marr (2015) these concepts are referring to the challenges of a data mining system regarding the acquisition, usability and final added value of the collected data. In our theoretical framework, we shall try to integrate the production/process improvement and business analytics department. The basic corrugated factory, due to easier overview, will constitute from one corrugator, one flexo printing and die-cutting machine and one flexo folder gluer. The information stream will be separated into four levels and in four output users. The terminology and levels were adopted from Marr (2015). The four most important layers are:

- Data source layer (all sensor data and other machine information comes here, customer database, sales records, etc.)
- Data storage layer (distributed file system where all real-time and other data are stored)
- Data processing and Analysis where data is reduced with tools like MapReduce, and is prioritised to be analysed
- Data output layer where the end user is presented with statistics or Key Performance Indicators (KPI)

The data is streamlined and adapted for users/customers, financial users, internal processes/production and employees.

The data source layer would be collecting data from online continuous data measurement system regarding internal logistics (paper rolls) into and out from the warehouse to the corrugators. The system can be solved using RFID labels or other smart labels with geo positioning in the paper roll warehouse. The warehouse has to have a weather station which sends data regarding relative humidity and temperature, which affect the runnability properties of the used papers. The corrugators can be equipped with inline measurement system for adhesive preparation, inline paper roll temperature measurement during the preheating, and viscosity measurement of the starch adhesive. After glueing the separate layers, additional inline measurement devices would be installed for humidity, surface cleannliness and mechanical properties such as tensile strength, stiffness and warping. The machine's internal control system is a part of the Big Data system regarding speed and other machine's specific sensor data connected to the control screen. The data gathered from the machine can be used further for back-looping any warping or other corrugating problems (based on collected data) in the process and should be send to quality control and to the next machine in line, to adjust machine settings according to the already produced corrugated board. If the values are out of limits, the software automatically reschedules the job and cancel any bad material going further up in the process and making downtime on other machines. This data also goes to the financial users, employees concerned and supply chain management (regarding stock change).

The data feed can be used to predict any printing or converting problems based on the humidity and mechanical properties of the made corrugated board. For example, too low humidity will increase the possibility of cracking of die-cut and crease lines. The thickness or calliper of the board can also be used as a predictor for the flexo printing machine to adjust the gap between rolls and other transport elements which may alter the mechanical properties of the produced board.

On a flexo printing and die-cutting machine, the inline measurement of printing ink viscosity, colour values and die-cutting and creasing quality, respectively, can be monitored constantly to streamline the production process. The data from the creasing and die-cutting operation are transferred to the next working station, the flexo folder gluer, which has internal control (glue viscosity, glue gap detection and the side joining image processing), which is interconnected to the mechanical properties of the board and cutting and creasing quality.

All data (bad quality, rework, etc.) is stored for post analysis and data-based error prediction, while financial data of costs are automatically updated in the business part of the system. The production data is also stored per user for post analysis and prediction. The data mining and predictive analysis can be used to improve the productivity with sending data from the converting machines to the board producing machines for the current or next production.

5. Conclusion

The automation and the information technology supported analytics possibilities are widespread in different industry segments. They are widely used for marketing research and consumer behaviour analysis and modelling, while manufacturing examples are mainly used in closed-loop systems like the paper machines, which are fully automated. Printing industry has not yet adopted the full possibilities of the current technologies due to limiting factors, as not fully automated systems, incompatible data protocols and not fully developed possibilities in current solutions like JDF. There are gaps regarding sensor possibilities, connection and communication, and overall software implementations. They are mainly developed for the business side like downtimes, production speed and other parameters (scheduling, production cost), which can be combined into valuable key indicators or for example Overall Equipment Efficiency (OEE) ratings. On the other hand, production and process solving issues are still made in offline mode using traditional statistical software or not networked solutions. It seems that the printing industry will need a big leap forward in catching Industry 4.0 possibilities regarding data mining and analytic techniques for process improvement.

References

Alzghoul, A., Verikas, A., Hållander, M., Bacauskiene, M. and Gelzinis, A., 2009. Screening paper runnability in a web-offset pressroom by data mining. In: P. Perner, ed. *ICDM: Advances in Data Mining. Applications and Theoretical Aspects, 9th Industrial Conference*. Leipzig, Germany, 20–22 July 2009. Berlin, Heidelberg: Springer.

Bamberger, W. and Nicolas, A., 2005. Innovative trends in automation. *twogether: Paper Technology Journal*, 19, pp. 56–59.

Bullinaria, J.A., 2004. Self Organizing Maps: Fundamentals, *Introduction to Neural Networks*. [online] Available at: <http://www.cs.bham.ac.uk/~jxb/NN/l16.pdf> [Accessed 23 May 2017].

Bijlani, N. and Brauer, E., eds., 2016. *Data Mining for the Masses, Second Edition: with Implementations in RapidMiner and R*. North Charleston, USA: CreateSpace Independent Publishing Platform.

CEPI, 2017. *Key Statistics 2016*. [online] Available at: <http://digibook.digi-work.com/Digibooks.aspx/Get/cepi/1641/KeyStatistics2016_Finalpdf> [Accessed 17 May 2017].

Cielen, D., Meyman, A.D.B. and Ali, M., 2016. *Introducing Data Science: Big data, Machine Learning, and more, using Python tools*. Shelter Island, USA: Manning publications.

Ejsmont, K., Krystosiak, K. and Lipiak, J., 2015. Application of selected data mining technique in printing industry. In: *Conference: Polish Association for Production Management*. Zakopane, 2015. Opole, Poland: Publishing House of The Polish Society of Production Management, pp. 75–86.

Evans, B. and Fisher, D., 1994. Overcoming process delays with decision tree induction. *IEEE Expert*, 9(1), pp. 60–66.

Fu, J. and Hart, P.W., 2016. Leveraging mill-wide big data sets for process and quality improvement in paperboard production. *Tappi Journal*, 15(5), pp. 309–319.

Gaudard, M., Ramsey, P. and Stephens, M., 2006. *Interactive Data Mining and Design of Experiments: the JMP® Partition and Custom Design Platforms*. [pdf] Cary, NC, USA: JMP. Available at: <https://www.jmp.com/content/dam/jmp/documents/fr/events/explorers-resources/372455_interactive_datamining.pdf> [Accessed 9 May 2017].

George, M.L., Rowlads, D., Price, M. and Maxey, J., 2005. *The Lean Six Sigma Pocket Toolbook: A Quick Reference Guide to Nearly 100 Tools for Improving Process Quality, Speed, and Complexity*. New York: McGraw-Hill.

Gerard Leloup, L., 2002. *Measurement and Prediction Procedures for Printability in Flexography*. Doctoral Dissertation. Stockholm: Royal Institute of Technology.

Gough, B., Meade, D., England, G. and Kovac, S., 2007. Model-based predictive adaptive control of pulp and paper mill processes. In: *TAPPI Papermakers and PIMA International Leadership Conference*. Jacksonville, FL, USA, 11–15 March 2007. Peachtree Corners, GA, USA: TAPPI.

Hämäläinen, J., Madetoja, E. and Ruotsalainen, H., 2010. Simulation-based optimization and decision support for conflicting objectives in papermaking. *Nordic Pulp & Paper Research Journal*, 25(3), pp. 405–410.

Hassani, H. and Silva, E.S., 2015. Forecasting with Big Data: a review. *Annals of Data Science*, 2(1), pp. 5–19.

Hornbuckle, S., 2016. *Predictive Analytics: The New Productivity Weapon For Commercial Printers.* [online] Available at: <http://whattheythink.com/articles/81150-predictive-analytics-productivity-commercial-printing/> [Accessed 17 May 2017].

Jackson, C., 2011. Turning data into action. *Journal of Science and Technology for Forest Products and Processes*, 1(2), pp. 30–37.

Jansson, J., Lindberg, T., Dahlquist, E. and Persson, U., 2004. Process optimization and model based control in pulp industry. *TAPPSA Journal, African Pulp and Paper Week 2004*. [online]. Available at: <http://www.tappsa.co.za/archive2/APPW_2004/Title2004/Process_optimization/process_optimization.html> [Accessed 17 May 2017].

Kaestner, A.P. and Nilsson, C.M., 2003. Estimating the relative shrinkage profile of newsprint. *Optical Engineering: the Journal of SPIE*, 42(5), pp. 1467–1475.

Linnala, M. and Hämäläinen, J., 2001. Improvement of cost efficiency in papermaking with optimization tools. *Journal of Science & Technology for Forest Products and Processes*, 1(2), pp. 71–76.

Lundström, J., 2014. *Situation Awareness in Colour Printing and Beyond*. Doctoral Thesis. Halmstad University.

Marr, B., 2015. *Big Data: Using SMART Big Data, Analytics and Metrics to Make Better Decisions and Improve Performance*. Chichester: John Wiley & Sons.

Matulaitienė, A. and Jurkonis, E., 2013. Statistical analysis of the flexographic printing quality. *Science – Future of Lithuania / Mokslas – Lietuvos Ateitis*, 5(6), pp. 598–600.

Parola, M., Kaljunen, T., Beletski, N. and Paukku, J., 2003. Analysing printing press runnability by data mining. In: *TAGA Proceedings 2003 Conference: 55th annual conference*. Montreal, QC, Canada: 6–9 April 2003, pp. 14–17.

Pepperl+Fuchs Inc., 2012. *Sensors for the Printing Industry*. Twinsburg, USA: Peperl+Fuchs Inc. [pdf] Available at: <http://dsassets.s3.amazonaws.com/Auburn-Armature/SensorsforthePrintingIndustryFlyer.pdf> [Accessed 21 May 2017].

Practicanalytics, 2011. [online] Available at: < https://practicanalytics.files.wordpress.com/2011/04/whatisbi.jpg> [Accessed 11 June 2017].

PwC, 2016. *Industry 4.0: Building the digital enterprise: Forest, paper and packaging key findings*. PwC. [pdf] Available at: <https://www.pwc.com/gx/en/forest-paper-packaging/pdf/forest-paper-packaging-key-findings.pdf> [Accessed 8 May 2017].

Shankar, N.G., Ravi, N. and Zhong, Z.W., 2009. A real-time print-defect detection system for web offset printing. *Measurement*, 42(5), pp. 645–652.

Schmarzo, B., 2014. *Business Analytics: Moving From Descriptive To Predictive Analytics*. Dell EMC Services. [online] Available at: <https://infocus.emc.com/william_schmarzo/business-analytics-moving-from-descriptive-to-predictive-analytics/> [Accessed 21 May 2017].

SpencerLab, 2017. *Productivity: Utilization & Availability*. Melville, NY, USA: SpencerLab. [online] Available at: <http://www.spencerlab.com/testing/productivity/> [Accessed 11 June 2017].

Srivastava, T., 2015. *Difference between Machine Learning & Statistical Modeling*. [online] Available at: <https://www.analyticsvidhya.com/blog/2015/07/difference-machine-learning-statistical-modeling/> [Accessed 11 June 2017].

Stibl, B. and Natterer, S., 2005. Voith process solutions – wet end process analysis as the foundation of an optimization of paper quality and process stability. *twogether: Paper Technology Journal*, 19, pp. 48–51.

Verikas, A., Malmqvist, K. and Bergman, L., 2000. Neural networks based colour measuring for process monitoring and control in multicoloured newspaper printing. *Neural Computing & Applications*, 9(3), pp. 227–242.

TOPICALITIES

Edited by Markéta Držková

CONTENTS

News & more

Recently completed EU-funded research projects

Dozens of projects focused on the development of advanced materials for printing applications, novel printed devices, innovative machines, or simply implementing state-of-the art technologies in production facilities, have been completed in past months – from the small, mostly networking ones, over the standard research projects or to a special group targeted ones, up to the large-scale integrating projects, running from a few months to several years. Those with final report available are briefly summarised here, all funded under the 7th Framework Programme.

PICKNPACK – Flexible robotic systems for automated adaptive packaging of fresh and processed food products

This four-year project finished in September 2016 developed three types of modules that can cope with the typical variability of food products and the requirements of the food sector regarding hygiene, economics and adaptability. The designed system features flexible decoration module, receiving files from the central control system and printing the package just before sealing; it is based on inkjet technology and prints with 360 dpi resolution in two colours, extensible up to five or six colours.

MATFLEXEND – Materials for flexible energy harvesting devices

The project realised during three years till September 2016 focused on the development of novel, durable materials to facilitate effective energy harvesting, and also of rechargeable microbatteries for the buffering and smoothing of the harvested energy. The technology converting mechanical energy into electricity at low frequencies and low forces was enabled by the materials with a high dielectric constant (high-κ dielectrics), increasing the energy density of capacitive harvesters, and the flexible composite conductors based on an open porous polymer (synthesized within high internal phase emulsions) doped with conducting particles, improving conductivity more than two orders of magnitude over existing technology. For flexible rechargeable batteries, the conventional configuration with stacked electrodes and the coplanar electrode arrangement were tested, and their fabrication has been simplified by novel printable electrolytes and separators.

ARTESUN – Efficient, large-area arbitrary shape solar energy

This three-year project completed in October 2016 realised several versions of organic solar modules, building on the developments of novel active layer and electrode materials in combination with coating and module interconnect techniques that avoid the use of halogenated solvents, fullerene acceptors and indium tin oxide, and successfully demonstrated the potential of this technology for different application areas. The RFID tag sensing the indoor surrounding temperature is powered by an organic photovoltaic module, which combined with energy storage in form of a supercapacitor and overvoltage protection secures the operation up to one day during poor light conditions. The gravure-printed flexible organic solar antenna module with a flower-like design was used to power a radio and an environmental

Smithers Pira market reports
Signage and digital packaging print

Another two reports forecasting the trends for the upcoming five years to 2022 have been released by Smithers Pira in April and May, this time focused on the printed signage and the digital print for packaging, respectively.

According the data of the first one, the global market for printed signage will remain more or less the same as in 2017, with a value of about $46 billion and the volume of printed materials between 13 and 14 billion square metres. However, the industry is expected to undergo significant changes, such as meeting the shifting demands in retail point-of-sale signage, integrating new inks and substrates, and a growing share of inkjet print technology – also thanks to the arrival of a new generation of lower-priced wide-format presses. The attractive market opportunities are seen in Asia-Pacific, Eastern Europe, and Latin America emerging economies. Electronic signage developments are also covered.

For digital packaging market, which represents 3.25 % of all printed packaging in 2017, the rapid grow by almost 13 % (the compound annual growth rate) is forecasted, to exceed $22 billion in 2022. The print volume and tonnage are reported to grow much faster. The global data on end-use market values and prices are classified into six categories: labels, corrugated, folding cartons, flexible packaging, rigid plastics, and metal packaging. Among technology developments enabling the growth, food safe inks and coatings along with analytical methods for food safety testing are mentioned, besides the improvements of electrophotography and especially inkjet presses, and coding and marking developments.

Surveying the industry

The Printing Industries of America (PIA) Center for Economics and Print Management gathers data from print and graphic communications firms through Dynamic Ratios Survey to create the financial benchmarking industry report for the 2017–2018 fiscal year. Operations, profitability, sales factors, cost drivers, expenses, balance sheet statistics, funding ratios, leverage ratios, liquidity and activity ratios, value-added analysis, basic payroll data, employee profiles, inventory turnover, and billing cycles are all included in the report, with hundreds of participating companies. The survey is now open from May till August 2017. All who complete the questionnaire receive a free PDF copy of the final report. Each company thus can gain access to relevant financial and productivity benchmarks that can help the company to increase the efficiency, productivity, and profit.

In addition, all PIA members are invited to participate in the 2017 Member Needs Survey and share their preferences on future programming, resources, and offerings from PIA.

The Federation of European Screen Printers Associations (FESPA) is surveying the global speciality printing community to refresh the data for its market insight called Print Census. Optimism, customer demands, changing product mix, digital technology as change enabler, textile print growth, and the future of sign and display are still the key survey topics, with additional questions on sustainability. During the first Print Census, more than 1 200 surveys were completed; the second edition should extend its international reach even further. The survey can be completed online till 31 December 2017 or onsite by visitors to 2017 FESPA exhibitions, with the first answers collected at FESPA Asia in February. A summary of the results will be announced next year in May, at the FESPA 2018 in Berlin; the full analysis then will be freely available to FESPA members.

sensor in a distributed wireless sensor network, and optimised to operate under low or varying light intensities. The larger-area modules were produced and assembled in a glass-based ventilated façade element, with very promising results of potential market acceptability assessment.

SMARTONICS – Development of smart machines, tools and processes for the precision synthesis of nanomaterials with tailored properties for organic electronics

The output of this big project realised during 2013–2016 are three pilot to production lines for organic and printed electronics; (i) the roll-to-roll printing line combining optical sensing (spectroscopic ellipsometry, Raman spectroscopy), inkjet printing and laser processing tools for patterning and plasmonic nanoparticle formation, (ii) the organic vapour-phase deposition line for precision synthesis of small molecule nanomaterials and organic photovoltaics, equipped also with a metal deposition module and in-line optical sensing tools, and (iii) the sheet-to-sheet line for the precision fabrication of organic electronics devices and for the evaluation of encapsulation of these devices. The project comprised the development of several organic semiconductor nanomaterials with high upscalabilty potential, small molecule nanomaterials and films, plasmonic nanoparticles and processes for their fabrication by laser methods, the laser ablation methods for the synthesis of silver nanoparticles in solutions, the modelling of organic electronics devices, the novel optical tools and methodologies for the in-line monitoring of the optical properties, thickness and quality of nanomaterials and organic electronics architectures, the development of special inkjet printing system, and more.

MUJULIMA – Innovative materials for multiple junction OPVs and for improved light management

The aim of this three-year project completed also in December 2016 was to design and synthesise innovative photoactive materials as well as novel interlayer materials in order to achieve module efficiency above 15 %, employ up- and down-converter materials (IR to VIS/NIR and UV to VIS) for better spectral usage of the solar spectrum, and enhance the lifetime and stability of the modules by identifying and remediating the degradation mechanisms at material level and by improving the outdoor performance of encapsulation materials. To accomplish that, e.g. random copolymerisation of two electron-deficient monomers, variety of inorganic charge extraction and recombination materials, anti-reflective coatings and nano-imprint hardcoat were successfully applied.

PBFREEPEROVSKITES – Pb-free perovskites for efficient all-solid-state hybrid solar cells

This project that finished in January 2017 addressed the environmental and safety issues hindering commercial implementation of perovskite solar cells through the development of a new approach to form lead-free tin-based perovskite films, using more safe dioxane and methanol solvents instead of dimethylformamide. Many different perovskite structures were explored, leading to a number of publications and patent applications. Of great importance is also the use of these structures to prepare the first perovskite light-emitting diodes and light-emitting electrochemical cells. The developed perovskite materials re-emit nearly 90 % of absorbed photons as photoluminescence and may be used to achieve high-brightness near-infrared, green and red electroluminescence.

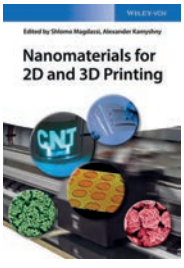
Bookshelf

Nanomaterials for 2D and 3D Printing

In general, nanomaterials are used to provide the required functionality either directly, or by the modification of other materials through the improvement of properties such as mechanical strength or biocompatibility. This comprehensive book contributed by 40 authors coming from all over the world presents different types of nanomaterials together with their formulation into inks suitable for production of various functional features and devices using an appropriate printing technique. The main advantage of printing is seen in the fact that it is an additive process, significantly reducing the amount of waste and bringing the possibility to develop products combining diverse materials and designs, even the complex ones, without the need for high-vacuum technologies. On the other hand, the challenges to be faced in the production of e.g. printed electronics devices on flat substrates, as well as when utilising the additive manufacturing fabrication processes, are also discussed.

Individual printing technologies, which are applied – or potentially applicable – for processing of functional nanomaterials, are reviewed in the first chapter. The fundamentals of both 2D and 3D printing processes are included, along with considerations regarding their benefits and drawbacks. A number of technical and other aspects important for the choice of a specific printing technology for a particular application are listed, such as resolution, feature definition, adhesion, process reliability and stability, manufacturing speed, device performance, production volume and cost, environmental impact, or safety of operators and customers. Among digital, non-contact techniques, which are advantageous for their flexibility on the fly and suitability for materials sensitive to mechanical pressure, inkjet printing and laser-induced forward transfer are explored. Within contact printing techniques with large potential for low-cost mass production, offset, flexographic, and gravure printing are described, along with microcontact and screen printing. Three groups of additive manufacturing techniques are introduced – patterning through direct deposition of a nanomaterial, definition of a pattern in a pre-deposited homogeneous material layer, and techniques combining both principles. Selected technologies are detailed in the following chapters, namely the inkjet printing with appropriate post-processing, electroless technologies, reactive inkjet printing, 3D printing via multiphoton polymerisation, and high-speed sintering.

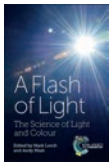
The remaining ten chapters deal with the preparation, characterisation and utilisation of various functional materials, from metallic and conducting polymer nanomaterials, over semiconducting and dielectric ones, to materials with special functionality, such as photonic crystals, low-melting-point metals and electrochromics. Their applications include printing of stretchable electrodes based on laser-induced forward transfer of silver nanowires, inkjet printing of functional polymers into carbon fibre composites, fabrication of thin-film transistors, sensors, displays, smart windows and many more.



Nanomaterials for 2D and 3D Printing
Editors: Shlomo Magdassi, Alexander Kamyshny
Publisher: Wiley-VCH
1st ed., June 2017
ISBN: 978-3-527-33819-1
376 pages
Hardcover
Available also as an eBook

A Flash of Light: The Science of Light and Colour

Editors: Mark Lorch, Andy Miah

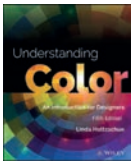


Publisher: Royal Society of Chemistry
1st ed., July 2016
ISBN: 978-1782627319
128 pages, Softcover
Also as an eBook

This popular science book originated as part of a novel experiment at the Manchester Science Festival, where the authors and illustrators supported by copy editors and a facilitator came together for a weekend and drafted nine chapters on light related topics, which were then edited and properly referenced. They explore where is colour, what we really see, how has light evolved in the Universe, why is the sunrise so colourful, why can't we believe everything we see, whether we can see the invisible – beyond the rainbow, what colour were dinosaurs, how can we see inside the body, and how do we make digital light.

Understanding Color: An Introduction for Designers

Author: Linda Holtzschue



Publisher: Wiley
5th ed., January 2017
ISBN: 978-1118920787
272 pages
Softcover
Also as an eBook

This book is an important and comprehensive resource for all who are interested in colour. Well organized, written in a clear and informative style, with a plenty of effective diagrams and illustrations including real design examples, it is considered a kind of bible ever since its 1st edition in 1994 – either it is read through or used as a reference. For the current edition, the content of the book (as well as the accompanying workbook) was further enhanced, e.g. with respect to the uses of colour, light sources, the colour rendering index, theoretical gray, colour management, colour consulting, and a concluding outlook.

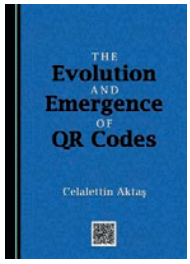
Color Quality of Semiconductor and Conventional Light Sources

With the content based on the research of its authors, the book reviews colour quality of solid-state light sources and conventional lamps in order to provide the current state of knowledge and help to understand, evaluate and optimise lighting systems and illumination with respect to colour rendition and also the nonvisual effects of light, in accordance with the strategy of human-centric lighting. Namely, as stated in the preface, the aim is to analyse the concepts of colour space, colour difference perception, white point appearance, the interaction between scene brightness, colour temperature and colour preference, and the relationship between coloured objects, light sources and the physiological and cognitive processing of the corresponding human photoreceptor signals. The methods, parameters, metrics, and measurement methodologies available for description of the subjective colour perception and colour quality impression are discussed, including visual colour quality experiments at the Technische Universität Darmstadt.

Color Quality of Semiconductor and Conventional Light Sources
Authors: Tran Q. Khanh, Peter Bodrogi, Trinh Q. Vinh
Publisher: Wiley-VCH
1st ed., April 2017
ISBN: 978-3-527-34166-5
384 pages
Hardcover
Available also as an eBook

The Evolution and Emergence of QR Codes

Investigation of communication technologies and new media introduced by the author in the first chapter gives the basic framework for the understanding of the QR (Quick Response) codes as a communication technology and new media opportunity. Technical characteristics of the QR code, its generation, standardisation, readability, functionality and efficiency are briefly explained in the second chapter. The use of QR codes in advertising and different media, from newspapers and books to television broadcasting and online communication, including ticketing and corporate identity, are presented in the next chapter. Limitations based on smartphone requirements, varying standards and issues with mobile websites are also introduced with a set of recommendations for widespread use of QR code based communication. The last chapter introduces the convergence of analogue and digital communication media based on QR code, with the impact of QR codes on the hybridization of contemporary and future social culture. The book may be recommended to anyone primarily interested in QR code hybrid communication and its effect on media and advertisement; however, some basic technical requirements are also given.



The Evolution and Emergence of QR Codes
Author: Celalettin Aktaş
Publisher: Cambridge Scholars Publishing
1st ed., April 2017
ISBN: 978-1-4438-5065-9
114 pages, 11 images
Hardcover

Managing Media Businesses:
A Game Plan to Navigate Disruption and Uncertainty

The intent of this book is to help the media and entertainment businesses to find a way to profitable and sustainable publishing of the content, while facing all rapid changes and uncertainty of current media landscape. To success in generating the revenue needed to support the creation and development of quality content, the managers have to change their mental models, presented as a frame that needs to be broken, and rebuild their set of managerial tools. In searching for an answer when considering the decisive questions, such as whether there is a future seen in newspapers, magazines or books, how to make money from digital ventures and how to achieve synergy of print and digital platforms, it is necessary to understand the core strength of the particular company and figure out how to make use of that strength in a new context. This implies also understanding of that new context, i.e. the new media world.

The content of the book is enriched with interviews from leading industry players and real-life case studies, and goes through trends, accounting basics, appropriate marketing, leadership, decision analysis, operations management, relevant business models, specifics of managing creative people, financial management, and utilisation of scenario planning.

Managing Media Businesses:
A Game Plan to Navigate Disruption and Uncertainty
Editors: Michael Rosenberg, Philip H. Seager
Publisher: Palgrave Macmillan
1st ed., May 2017
ISBN: 978-3-319-52020-9
223 pages, 30 images
Hardcover
Available also as an eBook

White Space Is Not Your Enemy:
A Beginner's Guide to Communicating Visually Through Graphic, Web & Multimedia Design

Already the first edition of this book has become a popular choice among readers with no or little design background who look for a resource to help on serious projects, thanks to its clear and engaging style, conveying the information in an easy-to-understand and logical way. Among the highly appreciated chapters belongs e.g. the one on a "Works-Every-Time" layout for situations when a design must be done quickly but still with the required quality. The changes in the current edition further improve the content and graphics and extend the coverage by current web design trends – mobile first, user interface and experience design, and web typography practices.

White Space Is Not Your Enemy:
A Beginner's Guide to Communicating Visually Through Graphic, Web & Multimedia Design
Authors: Rebecca Hagen, Kim Golombisky
Publisher: CRC Press
3rd ed., October 2016
ISBN: 978-1-138-80464-7
292 pages, 286 images, Softcover
Available also as an eBook

Design By Thinking:
One hundred thoughts about corporate and brand identity

Author: Ken Cato

Publisher:
Images
1st ed., July 2016
ISBN: 978-1864706659
128 pages, 175 images
Hardcover

This volume opens the Design By Thinking series, which is compiled by the author who has deep experience in corporate and brand management and design and builds upon his book of the same name, published in 2000. This part presents a hundred advices how to create well known and recognisable design with the strong core idea, such as 'Utilise all resources', 'Symbolise the narrative', or 'Remember the message'. Each point has a brief commentary and is illustrated with real examples.

Book Cover Design from East Asia

Author: Céline Leterme, Jon Dowling

Publisher:
Counter-Print
1st ed., June 2016
ISBN: 978-0957081697
112 pages
Softcover

The selection of over 100 book covers from China, Japan, Korea and Taiwan is presented in a pocket-sized edition.

Graphic Design Visionaries

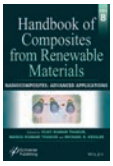
Author: Caroline Roberts

Publisher:
Laurence King
1st ed., June 2015
ISBN: 978-1780674841
312 pages, 340 images
Softcover

This reference in chronological order presents the career and work of 75 of designers and groups who moved the 20th century design a step further.

Handbook of Composites from Renewable Materials: Volume 8 – Nanocomposites: Advanced Applications

Editors: Vijay K. Thakur, Manju K. Thakur, Michael R. Kessler



Publisher: Wiley-Scrivener
1st ed., April 2017
ISBN: 978-1119223832
650 pages
Hardcover

After the first volumes covering the structure and chemistry, design and manufacturing, physico-chemical and mechanical characterisation, and functionalisation of renewable composites, the handbook reviews biodegradable materials, polymeric composites, and nanocomposites. The science and fundamentals of nanocomposites, included in the previous volume, are complemented by their applications in this final one. It deals for example with water and wastewater treatments and other environmental applications, electroanalytical, antimicrobial, biomedical and dental applications, applications in tissue engineering, drug delivery, energy generation, sensors, bio- and food packaging, as well as in the paper industry.

Sustainable Solvents: Perspectives from Research, Business and International Policy

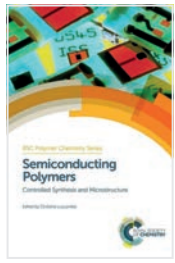
Authors: James H. Clark, Andrew J. Hunt, Corrado Topi, Giulia Paggiola, James Sherwood

Publisher: Royal Society of Chemistry
1st ed., May 2017
ISBN: 978-1782623359
431 pages, Hardcover
Also as an eBook

The authors bring a throughout overview of the topic, introducing the basic concepts and modern trends in solvent use, sustainability assessment, standards and certification, bio-based solvents, various speciality solvents, green solvents, and over a hundred pages of solvent data sheets.

Semiconducting Polymers: Controlled Synthesis and Microstructure

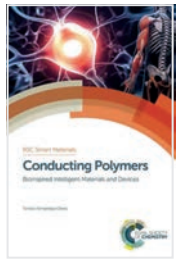
The advances in the performance of semiconducting polymers have enabled a significant growth in the field of organic electronics, which benefits from the ability of these materials to move charges and to absorb and emit light in combination with their flexibility and solution processability. The syntheses of π-conjugated polymers with complex structures have allowed to achieve higher charge mobilities and to increase the efficiency of organic electronics devices. However, there is still room for improvement. This book focuses on the possibilities to control the synthesis of semiconducting polymers in order to get the required molecular weight, to narrow molecular weight distribution, to avoid random end-groups, and to ensure an overall increase in reproducibility, important for the production of reliable devices. Such polymers also allow to determine how the polymer structure affects its properties. The first section of the book reviews the development of monomers and catalysts for controlled polymerisation and the resulting polymer architectures. The second section then presents the latest characterisation techniques, e.g. the neutron scattering techniques, solid-state nuclear magnetic resonance, and grazing incidence scattering, and discusses the application of structural control to the manipulation of light-emitting properties.



Semiconducting Polymers:
Controlled Synthesis and Microstructure
Editor: Christine Luscombe
Publisher: Royal Society of Chemistry
1st ed., October 2016
ISBN: 978-1-78262-034-1
291 pages
Hardcover
Available also as an eBook

Conducting Polymers: Bioinspired Intelligent Materials and Devices

This book presents conducting polymers as organic materials that offer a wide range of unique electromechanical and electrochromic characteristics, which can be reversibly tuned through electrochemical reactions. The electrochemistry of conducting polymers as reactive gels mimicking the composition of the intracellular matrix in living cells is described, as well as the complex mechanism of their electrosynthesis. The author discusses electrochemical reactions of gel membrane electrodes and their properties dependent on membrane composition, corresponding reaction-driven conformational, allosteric and structural changes, along with their theoretical description, and applications in electro-chemo-biomimetic devices, from artificial muscles up to devices mimicking brain–organ intercommunication.



Conducting Polymers:
Bioinspired Intelligent Materials and Devices
Author: Toribio F. Otero
Publisher: Royal Society of Chemistry
1st ed., November 2015
ISBN: 978-1-78262-315-1
268 pages
Hardcover
Available also as an eBook

Bookshelf

Academic dissertations

Printed Components for Organic Optoelectronics

Doctoral thesis – Summary

Author:
Aniello Falco

Speciality field:
Nanoelectronics – Organic and Printed Electronics

Supervisor:
Paolo Lugli

Defended:
9 November 2016, Technical University of Munich, Institute for Nanoelectronics Munich, Germany

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Aiming towards the realisation of devices and processes capable of simplifying the way to organic neuroelectronics, this dissertation systematically deals with several aspects connected with the development of reliable, durable and cost-effective solutions. The steps taken to meet the goal are introduced, always explaining the need for given step, underlying principles and the chosen approach. Chapter 2 reviews organic semiconductors and their working principle, two case studies on organic bioelectronics along with its important advantages and drawbacks, and spin coating, inkjet printing and spray deposition as relevant deposition techniques used throughout the dissertation. The next chapter describes example realisations of conformal organic electronic devices. Namely, the fabrication and optimisation of carbon nanotubes based organic photodiodes and subsequently of the fully solution-processable ones, making use of ultrathin polyethylenimine layers acting as work-function modifiers; finally, the development of RFID tag with inkjet-printed dipole antenna and integrated fully spray-deposited photodetector is presented. Then, the stability of materials in different media is considered and assessed through one-month experiments; inline thin-film encapsulation is utilised to ensure sufficient durability of functional layers and adhesion layers are applied to prevent the delamination of metallic electrodes. The biocompatibility of metals is also investigated. Following two chapters are focused on integration of organic electronics in more complex systems. Vertical (monolithic) integration is explored through embedding optical field polarisers in organic optoelectronic devices, thus introducing a new class of devices – polarised organic photodiodes and polarised organic light emitting diodes, where a thin transparent electrode is substituted with a wire grid polariser. Finally, the designed system enabling 3D printing and spray deposition of arbitrary materials is used to fabricate a fully-printed semi-transparent perfusion chamber as a proof of concept, utilising spray deposition also for planarisation of 3D-printed substrate to improve the functionality of organic thin films.

Electrical Performance and Use in Logic of Printed Current Switching Transistors Employing Nanostructured Silicon

Doctoral thesis – Summary

Author:
Serges Zambou

Speciality field:
Device Physics

Supervisors:
David Thomas Britton, Margit Härting

Degree Conferral:
20 December 2016, University of Cape Town, Department of Physics Cape Town, Republic of South Africa

Contact:
zmbser001@myuct.ac.za

This thesis elaborates the design, production and throughout characterisation of a novel, fully printed current-driven switch, further referred to as CST (Current Switching Transistor). The CST devices were screen-printed on flexible paper substrates at room temperature using nanostructured silicon material to form an active layer. Their conduction mechanism is shown to be based on the activated percolation of charge carriers through the network of silicon particles. This, in combination with the operation mechanism of the CST, consisting in switching the preferred carrier path between pairs of terminals once the carriers have enough energy to cross internal barriers in the material, enables to switch also an alternating current signal. The CST thus offers a unique ability to operate as a two-way switch for both direct and alternating current. To achieve an in-depth understanding, the performance of CSTs with various designs and dimensions was tested under thermal and bias stress to study their behaviour, stability and reliability.

After introducing the topic and providing the necessary background, the research is detailed in four chapters. The main part starts with the parameters, architecture and designs of CSTs, both asymmetric and symmetric, followed by the description of materials and methods for their production, from the top-down approach to silicon powder production and water-based ink formulation, rheology and stability, over the deposition by screen printing, to the structure of printed silicon and silver ink layers, and then the electrical characterisation and temperature dependence measurement of the transfer characteristics in an extended range of 340 to 10 K. Next, the successful use of printed CSTs for the fabrication of flexible logic gates for two basic Boolean operations, AND and OR, is described, utilising the combination of two transistors in series and in parallel, respectively. Further, in testing the performance and characteristics of different CST designs, the temperature and bias stress influence is investigated. The devices proved to be highly stable even at temperatures as low as 10 K, with the transistors on/off ratio being the highest at temperatures below 150 K, making them promising candidates for cryogenic applications. As the final step, the CST switching under alternating current is explored, proving the possibility to use both tested designs alternatively in direct and alternating current without a noticeable change in their transfer characteristics. Each of these chapters is concluded by a discussion of presented results, summarised in the last chapter.

Doctoral thesis – Summary

Author:
Jure Ahtik

Speciality field:
Graphic and Interactive Communications

Supervisor:
Marica Starešinič

Defended:
26 June 2017, University of Ljubljana, Faculty of Natural Sciences and Engineering Ljubljana, Slovenia

Language:
Slovenian

Contact:
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The Correlation between Objective and Subjective Digital Photography Quality Assessment and Its Communication Value

Focused on the impact of visual quality of an image on the message it communicates, this dissertation describes its assessment through an evaluation of various quality parameters using both objective and subjective methods, adding to the recent extensive research in this area. The objectives were to investigate the correlation of the visual quality of a digital photograph as evaluated by both types of methods, searching for the objective quality thresholds corresponding to the acceptability of photographs for the observer resulting from the subjective assessment, and to analyse how the decrease in individual quality parameters impairs the message of given image.

The introduction identifies the research problem and outlines the approach and methods, which are further detailed in the main part. The terms and theory related to visual image quality and relevant parameters are presented, along with the options of objective and subjective evaluation. Among objective methods, the calculations of root-mean-square error, peak signal-to-noise ratio, structural similarity index and colour differences are used, as well as the eye movement tracking to determine the message of images. The experimental section starts with a basic test photographic database and continues with individual image quality parameters considered – the sharpness, brightness, contrast, noise, colour saturation, compression, and resampling. The resulting database contains accordingly modified images and their visual quality is studied using the objective calculations comparing the reference and test photography, the eye tracking method, and the subjective assessment. The closing chapters discuss the results gained by these three methods, analyse their correlations and draw the conclusions. It was shown that the evaluation of image quality by objective calculations corresponds with the subjective one only in case of parameters related to illumination; however, it was possible to reliably determine the importance of individual parameters. The developed web application represents the efficient tool for fast collection of subjective image assessment data for a large number of evaluators.

Events

NANOTEXNOLOGY 2017

Thessaloniki, Greece
1–8 July 2017

The programme of this big international scientific and technology gathering in flexible, organic and printed electronics combines in 2017 the four established events – the two conferences running in plenary and parallel sessions and the related exhibition, all framed by the complementary summer schools – with the business forum featuring the start-up area, the matchmaking B2B event between technology developers and technology users, and several special workshops. For example, the EU–USA Workshop 'Bridging Research Cooperation in NanoManufacturing' organised on 7 July should foster the collaboration in the field and create a sustainable and synergic framework. NANOTEXNOLOGY has also offered the representatives from EU funded R&D projects the opportunity to present their latest activities and advances; there are almost thirty of them in the schedule.

The conference in nanosciences and nanotechnologies features, among others, the contributions dealing with the application of inkjet printing for deposition process of metalorganic precursors to reach oxide superconducting thick films, the technology for printed organic photovoltaics, and the utilisation of silver-doped zinc oxide on screen-printed electrodes for electrochemical signalling of Bisphenol A. The lectures of the flexible organic electronics symposium present the progress in organic and printed photovoltaics, flexible thin-film-transistor arrays, hybrid light emitting diodes, combination of printed features into a fluorescent light detector, 3D printing of multiple functional materials, large-area manufacturing with inline quality control, solutions combining organic and inorganic materials (e.g. transistors based on inkjet-printed zinc tin oxide and different organic dielectrics, or non-volatile resistive memories based on a hybrid organic/inorganic functional ink), challenges of rechargeable printed batteries, and many more. Further, the example applications spanning from automotive over textile electrodes for biopotential recording to ingestible electronics, as well as the related industrial trends in some countries, are included.

Droplets 2017

DROPLETS 2017 Los Angeles, California, USA
24–26 July 2017

As expressed by its straightforward name, this international workshop encompasses the research in droplets, covering experimental, theoretical, and industrial perspectives. The programme of the third edition is organised into parallel, mostly multipart sessions, running in two tracks and dealing with impact, evaporation and breakup, superhydrophobic surfaces, wetting and electrowetting, thin films, complex systems, emulsions and colloids. It offers e.g. the contributions discussing the effect of particle wettability on the stick-slip behaviour of inkjet-printed droplets and characterisation of complex fluids in microfluidic and printing applications.

Printing of Functional Applications
Summer School

Swansea, UK
10–14 July 2017

This already established summer school, hosted by the Welsh Centre for Printing and Coating (WCPC), started within the COST Action FP1104 New possibilities for print media and packaging – combining print with digital, and successfully continues with the support of COST Action FP1405 Active and intelligent fibre-based packaging – innovation and market introduction (ActInPak). The lectures for 2017 have been partly modified, with the new ones e.g. on photonic curing applications, electrostatic jet technology for super-fine deposition, and automated control of web transportation.

Serigrafia SIGN FutureTEXTIL 2017

São Paulo, Brazil
12–15 July 2017

In addition to the proven offer, this trade fair for the visual communication and printing segments in Latin America has this year introduced the opportunity of establishing relations with partner financial institutions for both visitors and exhibitors.

PackPlus 2017

New Delhi, India
3–6 August 2017

For 2017, the annual International Packaging Conclave, organised on the second day of this Asian fair for the whole packaging, processing and supply chain, has chosen the topic of packaging safety and compliance.

SPIE Optics & Photonics 2017

San Diego, California, USA
6–10 August 2017

With the four conferences consisting of numerous symposia covering the research in various application areas, this is the largest multidisciplinary optical sciences meeting in North America. The presentations of the research utilising some printing technique can be found across many sessions, with the examples of novel applications as well as the advances in already established ones, including field-effect transistors, light-emitting diodes, memory devices, sensors, solar cells, etc. Besides the more commonly applied printing processes, also organic vapour-jet printing or a conventional office laser printer are utilised. The contributions range from those exploring new challenges up to the mature, large-area examples.

One of the Monday plenary keynotes in Nanoscience & Engineering focuses on the scientific progress, engineering achievements, and commercialisation of flexible and printable 2D atomically thin materials, such as graphene, transition metal dichalcogenides, phosphorus, and Xenes, i.e. silicene, germanene, and stanene, along with corresponding devices. Among invited papers, printing applications e.g. in fabrication of biomimetic sensing devices and sensor array for nitroaromatic explosive vapour detection are represented.

Inkjet Ready!

Virtual event
9–10 August 2017

The programme goes through applications, adoption rate, and investing in high-speed inkjet, calculating costs and return on investment, evaluating technology and format choices, inks and substrates, decorating with inkjet, operational factors, implementing a new inkjet press, and finishing – all that with a number of case studies.

High-Performance Graphics 2017

Los Angeles, California, USA
28–30 July 2017

On top of the regular sessions dedicated to the research in performance-oriented graphics systems and two keynotes, the conference this year offers the special session on compilers and programming models, and two sessions connected to virtual and augmented reality – with Warren Hunt exploring the applicability of real-time ray-casting as an alternative to rasterisation, Donald Greenberg discussing the features of the 21st century design studio, and Dave Blizard revealing the best lighting practices for virtual reality development.

SIGGRAPH 2017

Los Angeles, California, USA
30 July to 3 August 2017

The five days of this annual conference and exhibition in computer graphics and interactive techniques are traditionally full of research results, demonstrations, educational sessions, art, screenings, hands-on interactivity, and commercial exhibits displaying the industry's latest advances in the field. Much of the conference content can be freely accessed online thanks to the Association for Computing Machinery's SIGGRAPH policy.

One of the contributions interesting for artists and graphic designers at this year's SIGGRAPH definitely is a prototype of an interactive parametric colour mixer for digital paint programs called Playful Palette. Its design is motivated by a pilot study of how artists use paint palettes. Among the important features belong the non-destructive editing thanks to the colour history wheel with an infinite history, enabling easy recolouring, and spatial arrangement capabilities that support the manipulation of colour spots blending together in search for the right gradients and gamuts.

ICFPE 2017
8th International Conference on Flexible and Printed Electronics

Jeju Island, Korea
4–7 September 2017

This event based in Eastern Asia starts in 2017 with three master classes on the first day, focused on additive manufacturing, fabrication solutions for flexible electronics, and emerging materials for printed and flexible electronics. The schedule for the next three days features five plenary speeches and sessions running in up to six tracks, offering a number of invited talks and including more than 15 special sessions organised by leading companies and research institutes in the field. These sessions, complementing the topics presented in general sessions, cover more specific subjects such as manufacturing challenges, emerging products, and overall outlook. The industrial session this year opens a discussion on what is needed to break the technological barrier and transition printed electronics from lab-scale demonstrations to commercial production.

44th International iarigai Conference
Advances in Printing and Media Technology

Fribourg, Switzerland
10–13 September 2017

The key conference themes for 2017 reflect the shift in the research employing printing technologies and include print for packaging, printed functionality, printing processes and products, with industrial processes and product development, as well as their sustainability, substrates for printing, 2D+ printing (2.5D/3D/4D), printing in life sciences, including bioprinting, and coating for/by printing – selective and structured coating. The event is this year hosted by the iPrint Institute of the School of Engineering and Architecture Fribourg, a member of the University of Applied Sciences of Western Switzerland.

The one of the plenary sessions is focused on the new dimensions of industrial printing and the other two on media and digital direct manufacturing, respectively. The announced scientific programme combines different facets of studies the field. Among others, the theoretical papers deal e.g. with modelling of inkjet printing on porous substrates, calculation of mesh depression during screen-printing process, and predictive modelling of demixing and evaporation from a roller nip-distributed water-in-ink thin film emulsion. The research in materials explores for example the formulation of a bio-based and water-based flexographic ink or the use of cheap carbon nanodots obtained from waste as luminescent material for inkjet inks. Presented characterisation methods encompass the microscale halftone analysis approach to differentiate physical and optical dot gain, the print quality control based on adaptable camera focus using power spectrum, the method to assess the cross-sectional profile of fused deposition modelling lines, and more.

PRINT 17

Chicago, Illinois, USA
10–14 September 2017

This exhibition produced by NPES (The Association for Suppliers of Printing, Publishing and Converting Technologies based in the USA) covers digital, inkjet, offset, flexography, gravure and hybrid technologies, products and services for the wide range of industries – commercial, transactional, converting and package printing, publishing, mailing, in-plant, digital imaging, marketing and industrial printing. PRINT 17 offers more than 50 education sessions in innovative formats, such as the new 'Distinguished Leader' speaker series, encompassing the design/creative process, packaging, marketing, growth strategies and emerging technologies topics. The Printing Industries of America Premier Print Awards and InterTech Technology Awards Gala takes place on the first day; during the exhibition, a technology review booklet showcasing all InterTech entries will be distributed as well.

Besides a plenty of other attractions, a project combining print and digital in educational publishing will be presented to attract potential supporters. Specifically, the 2007 textbook 'Introduction to Graphic Communication' by Harvey R. Levenson is now being updated, co-authored by John Parsons, to integrate print, video, and other digital content using Ricoh's Clickable Paper solution. A prototype sample of the book will be available.

WAN-IFRA Events

In the summer, the series of WAN-IFRA Academy trainings continues with the one on digital content monetisation in Hyderabad, India (16–17 August 2017). Later on, WAN-IFRA India Conference held this year in Chennai is forthcoming (12–14 September 2017), with Big Data among the key topics and South Asian Digital Media Awards 2017 ceremony. The next seminar within the eRev publishers network is then scheduled to 26–28 September 2017 in San Francisco, California, USA.

FESPA Events

The calendar of the FESPA events offers two big regional shows, offering a complete coverage of wide format digital printing, textile printing, screen printing, garment decoration, and signage, as well as commercial digital printing machinery and supplies. The first one is held in Johannesburg, Republic of South Africa on 13–15 September 2017, and the second one in Mexico City, Mexico a week later, 21–23 September 2017.

FESPA Africa 2017 is co-located with Sign Africa and Africa Print. There are also educational workshops and competitions to attend and gain hands-on experience.

FESPA Mexico 2017 celebrates the 10th anniversary of this event with the Print Mexico Congress – one day industry conference, and a number of free seminars during all three days.

Pack Print International 2017

Bangkok, Thailand
20–23 September 2017

The claim of the 6th edition of this exhibition organised in Southeast Asia every odd year is 'Packaging and printing for the future: from idea to shelf', expressing a renewed focus on packaging and coverage of the entire value chain.

ERA Annual Conference 2017

Nuremberg, Germany
25–26 September 2017

The conference theme 'Print in the digital world' defines the focus of several talks for this year, such as what to consider when going digital, how to take print publications online, and what is the role of print in the marketing of an international retailer. Other speakers will review publication paper demand, present heatset ink for the retail segment, give an update to the Process Standard Rotogravure for better colour communication between print buyers and gravure printers, and provide the information on chromium trioxide authorization status.

The participants can also visit one of the largest and most advanced publication gravure plants worldwide with nine presses in use, with web widths from 2,65 m upwards.

PACK EXPO 2017

Las Vegas, Nevada, USA
25–27 September 2017

This big packaging show features various free educational opportunities – the Innovation Stage with 30-minute seminars in three tracks, solutions for a more sustainable supply chain in the Reusable Packaging Learning Center, and attractive programs for engineering students, such as the Amazing Packaging Race where student teams solve challenges at participating exhibitors' booths.

Labelexpo Europe 2017

Brussels, Belgium
25–28 September 2017

The attendees of this show can learn about workflow automation, automated digital and conventional press lines, linerless labels, new materials, and other advances.

CIC25 – 25th Color and Imaging Conference

Lillehammer, Norway
11–15 September 2017

Two years after the successful 23rd edition held in Germany, this annual conference sponsored by the Society for Imaging Science and Technology returns to Europe.

The first two days offer short courses, with the new ones on camera colour characterisation, spectral filter arrays technology, perceptual display platform technology, colour 3D scanning and documentation process of cultural heritage objects, and the role of colour in counterfeit detection and deterrence solutions. On Wednesday, the main programme opens the keynote 'Computational photography and the rise of mobile imaging' by Paul Hubel, reviewing a steep rise in the popularity of mobile imaging in the past decade, discussing some of the successful methods that pushed the image quality of small cameras well beyond much larger systems, and giving a future outlook. The focal talk of Patrick Callet, dealing with a multiscale approach for characterising visual appearance, illustrated using automotive paints as an example, is scheduled later in the day. Thursday starts with the keynote of Anna Hurlbert, looking back at 'Twenty-five years of colour constancy' with relevant parallel developments in the computational and psychophysical approaches as well as highlighting the current challenges related to new developments in lighting technology. In closing keynote 'True colours: explorations in art, design, and research' by Malcolm Innes, the aim is to discuss whether colour metrics really help designers, reflect our real life experience of light and colour, and if we are actually measuring the right things.

For the second time, the International Symposium on Multispectral Colour Science is organised as a part of CIC. The 19th edition is scheduled on Friday afternoon, with the contributions complementing the conference programme, including workshops. Namely, a case study on the use of hyperspectral imaging for pigment identification adds to the one on cultural heritage, and preliminary results of infrared imaging spectroscopic system for the detection of skin cancer to the one on medical applications.

5th International Symposium on Sensor Science

Barcelona, Spain
27–29 September 2017

The conference is joined by scientists and engineers from different fields employed in sensor development. Printing is represented in four of the five oral sessions and within the poster exhibition. The applications include the chemosensor for selective detection of SO_2 based on silicon carbide screen-printed onto alumina substrates, the electrochemical lactate sensors for wearable implementations, the wearable sensor for real-time monitoring of sweat electrolytes developed using rapid prototyping technologies such as 3D printing, the nanobiosensor for detection of products containing genetically modified organisms, utilising the screen-printed carbon electrode, and more. The vision of structural, 3D-printed electronics will be also discussed.

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A PEER-REVIEWED QUARTERLY

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