

TOPICALITIES

Edited by Markéta Držková

CONTENTS

News & more	109
Bookshelf	111
Events	117

News & more

Recently ending EU-funded projects

This time, the regular overview includes the printing-related projects funded by Horizon 2020 and, in part, already by Horizon Europe, the EU's 7-year programmes for research and innovation. Besides the selection presented below, 3DBIOLUNG, which received the ERC Starting Grant, applied bioengineering approaches to generate constructs mimicking lung tissue using 3D bioprinting of hybrid bioink reinforced with extracellular matrix, and the innovation action Caladan used micro-transfer printing to incorporate lasers and electronics into photonic integrated circuits for efficient manufacturing of optical transceivers to increase communication throughput in data centres. Other examples include the Horizon Europe projects with the ERC Proof of Concept funding, dealing with in-situ monitoring for fused deposition modelling, novel support material for 3D bioprinting and post-printing tissue growth, 3D-printed electromagnetic interference shielding solutions based on 2D nanomaterials inks, and many more.

GrapheneCore3 – Graphene Flagship Core Project 3

Successfully building on the previous stages, see JPMTR Vol. 10, No. 2 (2021), also this third one, with a budget of 150 million EUR and about two hundred participants, contributed to the state of the art in graphene technologies.

RealNano – In-line and real-time digital nano-characterization technologies for the high yield manufacturing of flexible organic electronics

The outcomes of this research and innovation action include the tools and methods based on spectroscopic ellipsometry, Raman spectroscopy, imaging photoluminescence and laser beam induced current mapping for real-time and non-destructive in-line characterising, and analysing optical, structural, electrical and electronic properties of organic electronics materials and devices to significantly improve their performance and the manufacturing process control and reduce the development time and resources consumption.

RoLA-FLEX – Roll-2-roll and photolithography post-processed with laser digital technology for flexible photovoltaics and wearable displays

The progress made within this research and innovation action towards commercial flexible organic and large-area electronics, presented in over 20 papers, helped to develop organic photovoltaics with a significantly longer lifetime and an organic LCD prototype enabled by organic thin-film transistors.

PRIME – Advanced and versatile printing platform for the next generation of active microfluidic devices

This research and innovation action, aiming to integrate all the fluidic and sensing functions into a single device, involved the 4D printing of novel liquid crystal elastomers as smart materials responsive to temperature and light. The underlying research is described in about 20 papers.

Impressions from drupa 2024 sharing a positive spirit



Having the possibility to simply visit the fair, wander through the halls, let the exhibitors catch the attention by showcasing

their solutions, learn interesting details and gain insights into areas of particular interest, meet colleagues and share the news – that all may seem ordinary, but after the long eight years it just feels good.

The overall picture provided by this year's drupa fair is optimistic, with many new developments, partnerships and cooperations. In numbers, over 1 500 exhibitors filled almost every spot. Among nearly 50 countries, clear leaders were China and Germany, each with about 400 companies, followed by Italy with nearly 140, then India, the UK, the USA, the Netherlands and other, mainly European and Asian countries. Looking across the halls, the large exhibitors included Heidelberg, Müller Martini, Masterwork, Kolbus, Kurz, Kodak, Epson, Barberán, Horizon, Duplo, Canon, Ricoh, Screen, Kyocera, Fujifilm, Konica Minolta, Hanglory, Esko, Landa, EFI, Uflex, Bobst, Comexi, Uteco, UP Group, Line O Matic, Xeikon, Fangbang, Zenbo, Emmeci, Komori, Windmüller & Hölscher, Koenig & Bauer, Durst, RMGT, Manroland Goss, and HP. Regarding trends, the universal concept was automation, encountered in various contexts: as an integral aspect of digital machines, software and system solutions, an essential driver behind the increasing performance of all kinds of conventional equipment, and eye-catching robotic extensions and autonomous trolleys. Other clear trends include product portfolios adapting to the strength of the packaging sector and the emphasis on environmental considerations. The time for disruptive solutions exploiting the progress in artificial intelligence is yet to come.

The Intergraf activities during the last year

In the context of the ongoing digital transformation, several



Intergraf activities highlighted the role of print. The joint statement with Capi, UNI Europa Graphical & Packaging, FEPE, and IndustriAll Europe draws attention to essential paper and print products, aspects of their sustainability and circularity, benefits of reading in print for quality education and preventing the exclusion due to the excessive digitalisation, and the often omitted fact that the use of digital technologies is not environmentally neutral. With respect to environmental concerns, Intergraf, with other members of the World Print & Communication Forum, recognised the need for a common approach in the assessment of carbon footprint for the printing industry, and with UNI Europa Graphical & Packaging supported the European Parliament definitions of composite packaging, plastic packaging and high-quality recycling, and the coexistence of both reuse and recycling schemes, i.e. the concepts underlying the packaging and packaging waste regulation. Also, the first version of the Intergraf method for the assessment of environmental schemes for printed products was published in April. It defines the significant environmental parameters, following a life-cycle approach and adding the use of chemical substances in printed products, consumption of organic solvents and emissions of volatile organic solvents, along with classification criteria and the corresponding classification of environmental parameters.

In June, Intergraf released its regular annual reports. The Intergraf Activity Report provides an overview of the organisation and its operations in the past months. The relevant statistics collected in the 2024 Intergraf Economic Report mostly keep the values from the previous one. Considerable changes and differences among individual countries again show EU electricity prices, which are included in the market report section.

ApPEARS – Appearance Printing – European Advanced Research School

In this project, eight participating universities and research institutes with expertise in appearance characterisation have joined to facilitate innovative training of young scientists. The advances in the field are presented in dozens of scholarly publications, including a thesis assessing 2.5D print quality. Other topics include structural colourants, methods for reproducing the colour of translucent objects, 3D adaptive digital halftoning, and others.

T-Sense Cold – Printed temperature sensitive labels for products in cold chain

This project was funded through the SME Instrument and focused on developing a series of irreversible temperature-sensitive colour-changing labels for packages to increase the level of control across the whole cold supply chain. It comprised synthesising active materials, formulating inks, and thoroughly testing their functionality, safety, and sustainability.

ASTRABAT – All solid-state reliable battery for 2025

The objective of this research and innovation action was to contribute to developing a safe, high-energy, sustainable and marketable battery for green mobility. It addressed the challenges in terms of new materials for electrodes and electrolytes, including fluorine-free lithium salts and ionic liquid plasticizers, as well as cell architecture, eco-design, and manufacturing. Inkjet printing was proposed as a promising fabrication method for advanced 3D electrodes.

NewMEAT – New micro-extrusion advanced technology for plant-based whole-cut meat substitutes

This two-year project, funded within Horizon Europe under the European Innovation Council, utilised tissue engineering, food science and 3D printing to develop a micro-extrusion technology capable of mimicking the texture, appearance, flavour and nutritional properties of meat whole-cuts using a wide range of sustainable plant-based proteins and produce meat alternatives meeting consumer expectations at industrial scale.

PEP2D – Printable electronics on paper through 2D materials based inks

The published results of this long-term project that received the ERC Consolidator Grant present a wide range of low-dimensional materials and their use in different paper-based components and devices, including a novel anti-counterfeiting tag, naturally degradable photonic devices and many more.

PeroCUBE – High-performance large area organic perovskite devices for lighting, energy and pervasive communications

This innovation action explored new materials, device architectures and characterisation methods for perovskite photovoltaics and light-emitting diodes with a focus on their scalable manufacturing, e.g. by roll-to-roll printing.

SYMPHONY – Smart hybrid multimodal printed harvesting of energy

Among other outcomes of this research and innovation action, the energy-autonomous sensor system for smart tyres, which was integrated inside the bicycle tube, recently received the OE-A (Organic and Printed Electronics Association) award for the best publicly funded project demonstrator.

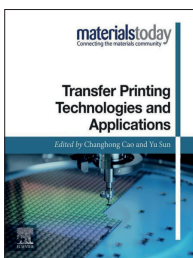
Bookshelf

Transfer Printing Technologies and Applications

This new book presents transfer printing as a highly versatile class of technologies for micro- and nanofabrication and deterministic large-scale assembly of various advanced materials or integrated devices. With almost 50 contributors, the book reflects the recent progress and aims to facilitate the choice of proper transfer-printing technique for a given application.

Eight chapters of the first part introduce the essential fundamentals of transfer printing, i.e. the analytical mechanical models, novel structures and functional materials, and then detail the individual methods, their working principles, specific characteristics and applications. The text describes the transfer printing by kinetic control of adhesion, with rate-dependent mechanical transfer of graphene as an example, the thermal release tape-enabled transfer printing techniques, where it discusses the mechanism of thermal release tape stamp with thermally expandable microspheres for large adhesion switchability, laser thermal treatment, shape-conformal thermal release tape stamp for curve electronics and roll-to-roll processing enabling large-scale transfer printing, and the laser-driven noncontact transfer printing technique making use of interfacial delamination. Further, it covers magnetic-assisted transfer printing techniques, transfer printing techniques enabled by advanced carbon nanomaterials, and water-assisted transfer printing techniques with self-assembled monolayer-based release layer or with sacrificial layer. Additionally it introduces novel nontraditional transfer printing technologies, which include the methods using shape memory polymer as a manipulator or a stamp coated with thin photoresist film, transfer printing of elastic membrane for pattern generation and epoxy-based subtractive transfer printing.

In the second part, nine chapters present the state-of-the-art applications in different areas enabled by transfer printing. These include optical systems, different types of flexible sensors, namely strain, pressure, thermal, electrophysiological and chemical sensors, flexible transistors based on Si, compound semiconductors, carbon materials, ion gel, oxides and other materials, functional devices for biomedical applications, micro-light-emitting diode display produced with contact or noncontact laser-driven transfer printing techniques, and energy systems, i.e. rechargeable batteries, supercapacitors, fuel cells and water splitting and solar cells. Among materials, the text deals with the transfer printing of metal films; it discusses environmentally-assisted bonding and debonding of the metal-substrate interfaces and the electromechanical behaviour of ultrathin metal films bonded on a substrate. It also describes the stacking of 2D materials and its implementation in electronics, namely 2D layer-based logic devices, optoelectronics and memories. The last chapter identifies the major challenges in transfer printing, e.g. high costs and limited scalability, and future research directions, such as hybrid materials, roll-to-roll printing, system integration and the Internet of Things.



Editors: Changhong Cao, Yu Sun

Publisher: Elsevier
1st ed., January 2024
ISBN: 978-0-443-18845-9
538 pages
Softcover
Available also as an eBook



Industrial Strategies and Solutions for 3D Printing Applications and Optimization

Editors: Hamid Reza Vanaei, Sofiane Khelladi, Abbas Tcharkhtchi

Publisher: Wiley
1st ed., March 2024
ISBN: 978-1394150304
320 pages
Hardcover
Also as an eBook



This book takes the interdisciplinary approach to encompass all aspects of the 3D printing process and properties of 3D-printed parts, with an emphasis on the importance of multi-objective evaluation. Written by 30 experts active in the field worldwide, the text highlights the essential features of 3D printing, discusses the possibility of upscaling in the context of state-of-the-art materials and techniques used in 3D printing, as well as the range of its applications, and identifies the current challenges. Further, it details the evaluation methods, controlling factors, physical and chemical properties of 3D-printed parts, rheology, mechanical performance, thermal modelling and temperature monitoring, along with the benefits of optimising and machine learning.

3D Printing and Sustainable Product Development

Editors: Mir I. U. Haq, Ankush Raina, Nida Naveed

Publisher: CRC Press
1st ed., September 2023
ISBN: 978-1032306803
240 pages, 60 images
Hardcover
Also as an eBook

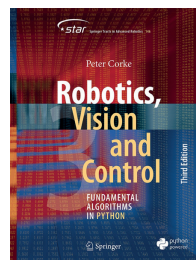


Also dealing with the fast progress in the field of additive manufacturing, this book identifies the opportunities and challenges of 3D printing in developing new products and reviews best practices to facilitate its industrialisation. It discusses the role of 3D printing towards sustainability and product safety, including the environmental impact

Robotics, Vision and Control Fundamental Algorithms in Python

This appreciated and informative book presents the title topics not only separately but also together as robotic vision. The author, with about 40 years of experience in the field, highlights the factors behind the fast evolution of robotics and machine vision of all kinds. Besides significant advances in computational power, sensors, cameras and other components and technologies, as well as their affordability, it is the open-source Robot Operating System platform and improvements in sensory data processing. Over ten years after the first edition, the current one uses Python with the relevant toolboxes ported from MATLAB. The algorithms in MATLAB are provided in the alternative third edition, coauthored by W. Jachimczyk and R. Pillat.

After the introduction, the content is divided into five parts. Foundations include the extensively rewritten chapter on representing position and orientation in 2D and 3D and another one dealing with aspects related to time and motion. Two parts present mobile robotics and robot manipulators, with an improved coverage of robot arm kinematics. The part dedicated to computer vision explains the concepts of light and colour, such as spectral representation, colour temperature, colour constancy, white balancing, dichromatic reflection and gamma. It also details methods for obtaining and processing images, feature extraction, image formation and use of multiple images. The last part deals with vision-based control, discussing both common and advanced visual servoing. The book also provides rich supplementary information.



Author: Peter Corke

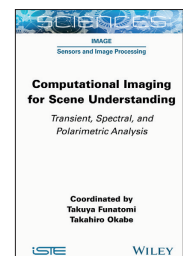
Publisher: Springer
3rd ed., August 2023
ISBN: 978-3-031-06468-5
850 pages, 635 images
Softcover
Available also as an eBook

Computational Imaging for Scene Understanding Transient, Spectral, and Polarimetric Analysis

About 20 authors of this new book review the recent progress in computer vision techniques beyond the usual RGB images captured at standard frame rates. The first part presents the approaches to transient imaging, including the methods for non-line-of-sight imaging, transient convolutional imaging using correlation image sensors, and time-of-flight rendering. The second part deals with hyperspectral imaging, obtaining the reflectance and fluorescence spectra from scenes, shape reconstruction of transparent objects,

Editors: Takuya Funatomi, Takahiro Okabe

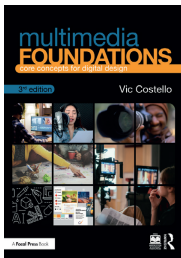
Publisher: Wiley-ISTE
1st ed., May 2024
ISBN: 978-1-789-45150-4
338 pages
Hardcover
Available also as an eBook



thermal photometric stereo, and synthetic wavelength imaging based on interferometry. The third part discusses polarimetric imaging, shape estimation using the shading and polarisation fusion approach, shape recovery in outdoor environments by considering polarised illumination, and multi-spectral polarisation filter array using a photonic crystal.

Multimedia Foundations Core Concepts for Digital Design

This revised edition incorporates the changes in multimedia technologies and their use in digital media production since the second edition published in 2016, building on the recent data. The text introduces the components of multimedia design and explains the related concepts, including design thinking, inclusive design, colour theory, interview, secondary footage acquisition techniques, and photography composition, exemplified by new illustrations. Also, it covers the main stages of the editing process and postproduction workflows. The content is organised into five sections, which deal with multimedia basics, asset management and project planning, elements and principles of visual design, text, graphics and photography, digital recording, audio and video production and non-linear editing, and interactive media. For this last section, Q. Xu revised the chapter on user interface design, and K. Furnas contributed the chapter on coding for web and mobile media.



Author: Vic Costello

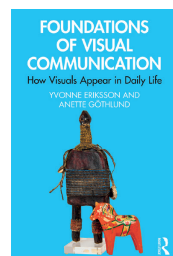
Publisher: Focal Press
3rd ed., July 2023
ISBN: 978-1-138-39153-6
512 pages, 376 images
Hardcover
Available also as an eBook

Foundations of Visual Communication How Visuals Appear in Daily Life

The authors of this book, illustrated by a variety of examples ranging from commonly encountered symbols, images and media to art history, focus on interaction with and among visuals. They discuss a changing visual landscape and intercultural influences, visual culture studies, factors shaping visual communication and its outcomes dependent on general or immediate context, individual perception and reception. The text also presents fundamental concepts and approaches to creating and interpreting visuals, visual cues, storytelling and interaction. The final chapter deals with visuals transforming in time and space and finding new roles.

Authors: Yvonne Eriksson, Anette Göthlund

Publisher: Routledge
1st ed., June 2023
ISBN: 978-0-367-77155-3
142 pages, 59 images
Hardcover
Available also as an eBook



of metal additive manufacturing and the use of polymeric materials based on spent coffee grounds and recycled polyethylene terephthalate. In addition, four chapters deal with dental and orthodontic applications, nanomaterials and 4D printing of magnetic-based robotic materials.

Designing Brand Identity A Comprehensive Guide to the World of Brands and Branding

Authors: Alina Wheeler, Rob Meyerson



Publisher: Wiley
6th ed., March 2024
ISBN: 978-1119984818
352 pages
Hardcover
Also as an eBook

The first part of this neatly arranged book explains the basic concepts of branding, brand ideals, elements, dynamics and redesign. The second one focuses on the design process, its important aspects and essential phases, i.e. conducting research, clarifying strategy, designing identity, creating touchpoints, and managing assets. The last part presents over 50 new case studies to highlight best practices. The current revised edition reflects the recent advances and changes, covering artificial intelligence, virtual reality, social justice and evidence-based marketing.

The Book of Printed Fabrics From the 16th Century Until Today

Author: Aziza Gril-Mariotte



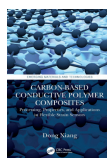
Publisher: Taschen
1st ed., April 2024
ISBN: 978-3836562768
888 pages
Hardcover
Also as an eBook

Page spreads of these two volumes present the hundreds of printed textiles from four continents, with a vast range of motifs carefully selected from a unique collection of the Musée de l'Impression sur Étoffes in Mulhouse and introduced in English, French and German.

Carbon-Based Conductive Polymer Composites Processing, Properties, and Applications in Flexible Strain Sensors

Author: Dong Xiang

Publisher: CRC Press
1st ed., February 2023
ISBN: 978-1032111582
175 pages, 87 images
Hardcover
Also as an eBook



This book deals with advances in conductive polymer composites based on carbon nanomaterials. It introduces their preparation, processing, and properties, as well as specially designed structures and applications in flexible strain sensors. It presents characteristics of compression moulded and biaxially stretched composites and blown film extrusion of different types of composites. Further, it discusses the stimuli-resistivity behaviour of carbon-based conductive polymer composites and details three types of flexible strain sensors, including those prepared by 3D printing.

Graphene Based Biomolecular Electronic Devices

Authors: Bansi D. Malhotra, Sharda Nara

Publisher: Elsevier
1st ed., January 2023
ISBN: 978-0128215418
262 pages
Softcover
Also as an eBook



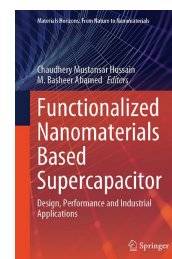
The authors of this book focus on the devices that make use of the charge transfer between graphene and biomolecules. After an overview of graphene fundamentals, they present graphene-based transduction systems in biosensors and graphene in biosensors based on field-effect transistors, protein and nucleic acid biosensors, wearable biosensors, microbial fuel cells and drug delivery systems. They also deal with 3D-printed graphene in bioelectronics and the prospects and challenges.

Functionalized Nanomaterials Based Supercapacitor Design, Performance and Industrial Applications

This comprehensive reference summarises the development of supercapacitors based on functionalised nanomaterials and in related areas. The first three parts provide the fundamental background. One chapter introduces nanotechnology, supercapacitors, functionalised nanomaterials and trends in their use as supercapacitor devices. The next details fabrication methods, including additive manufacturing of relevant functionalised nanomaterials, photolithography for supercapacitor electrodes, 3D printing and inkjet printing of supercapacitors together with recent advances in printable composite materials, and also the methods used for pre- and post-treatment of functionalised nanomaterials for supercapacitor electrodes. The third chapter is dedicated to functionalisation techniques for carbon-based nanomaterials, their forms and electrochemical properties, and the development of supercapacitors based on metal-oxide/hydroxides and conducting polymers. Then, four parts present the application possibilities in energy storage, the food and beverage industry, water treatment, health care and other emerging areas. The last two parts focus on the aspects of economics and commercialisation and discuss future development.

Editors: Chaudhery M. Hussain, M. Basheer Ahamed

Publisher: Springer
1st ed., September 2023
ISBN: 978-981-99-3020-3
713 pages, 243 images
Hardcover
Available also as an eBook

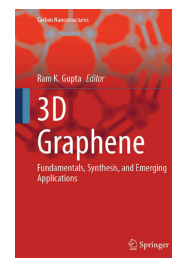


3D Graphene Fundamentals, Synthesis, and Emerging Applications

This volume reviews the progress in fabricating 3D graphene structures and their use. Three chapters introduce the unique properties of 3D graphene and describe its synthesis and printing. The next one deals with different architectures of 3D graphene and analyses relevant chemical aspects. The main part presents a wide range of applications. These include biosensors, electrochemical, optical and flexible sensors, remediating hydrogen sulfide gas, removing inorganic pollutants and pharmaceutical residues, metal-ion, metal-air, flexible and wearable batteries, flexible electronics, supercapacitors, photovoltaics, fuel cells, electrocatalysts and photocatalysts for water splitting, capacitive de-ionization of water and theranostic uses. Toxicity, stability, recycling and risk assessments are discussed in the last chapter.

Editor: Ram K. Gupta

Publisher: Springer
1st ed., July 2023
ISBN: 978-3-031-36248-4
449 pages, 130 images
Hardcover
Available also as an eBook



Bookshelf

Academic dissertations

Development of 3D Printable, Hydrophilic, and Rapidly Curing Silicone-Based Ink Formulations for Various Biomedical Applications

This thesis facilitated the progress in the 3D printing of elastic biomimetic structures towards higher precision needed to fabricate functional human-mimetic substitutes. The approach was based on developing silicone elastomer materials suitable for 3D micro-extrusion, namely UV-curable and hydrophilic ink formulations with tunable mechanical and rheological features to address the issues due to slow curing, low viscosity and hydrophobicity.

The dissertation provides the relevant background on 3D printing methods commonly used for bioprinting, 3D-printable biomaterials based on ceramics, different types of polymers, hydrogels and composites, collagen, carbon nanotubes and nanocellulose as additive components, and considerations regarding 3D printing in biomedical applications, especially for fabricating cartilage and microfluidic devices. The experimental work is described in two chapters. One details the development of inks with the desired characteristics achieved using the formulations consisting of aminosilicone to increase substrate affinity, cellulose nanocrystals as a hydrophilic nano-sized rheology modifier, and methacrylate anhydride with a photoinitiator for rapid curing, which enables creating the overhanging structures without supports. The developed hybrid inks and optimised printing parameters allowed the 3D printing of biocompatible human articular cartilage substitutes with a complex biomimetic multizonal 3D structure with a controlled change in stiffness and enhanced mechanical fastness. The work proposes a possible use of these novel inks also for in-situ surgical applications. The next step comprised the micro-extrusion of one developed ink to demonstrate the one-step and time-efficient fabrication of highly flexible microfluidic devices, including the T-junction and Y-channel types. Besides optimising basic printing parameters, attention was paid to the proper setting of bridging angle, bridge flow ratio and bridging speed to minimise sagging and blockage or leakage of microfluidic channels.

3D Printing and Electromagnetic Properties of Conductive Nanocarbon Based Composites

The research focus of this thesis was on the electrically conductive carbon nanocomposites with a low mass fraction of conductive component, allowing their production using digital light processing, and their potential use as electromagnetic wave absorbing materials in the microwave frequency range through dielectric losses. The approach comprised the development of novel transparent conductive acrylic resins based on graphene oxide and carbon nanotubes and tailoring the formulations and 3D printing process to achieve the required physical properties of resulting composites.

After a brief introduction, the text reviews relevant aspects of the 3D printing process and photosensitive resins for digital light processing, especially the electrically conductive nanocarbon-based composites. It highlights the properties of carbon nanotubes, graphene and graphene oxide and discusses the percolation influencing factors, including the geometry, orientation and dis-

Doctoral thesis – Summary

Author:

Hossein Golzar

Speciality field:

Chemistry – Nanotechnology

Supervisor:

Xiao-Wu Tang

Defended:

*20 December 2022,
University of Waterloo,
Department of Chemistry
Waterloo, Canada*

Contact:

hgolzar@uwaterloo.ca

Further reading:

<http://hdl.handle.net/10012/19072>

Doctoral thesis – Summary

Author:

David Tilve Martínez

Speciality field:

*Physical Chemistry
of Condensed Matter*

Supervisor:

Philippe Poulin

Defended:

*2 November 2023,
University of Bordeaux,
CRPP – Paul Pascal Research Centre
Bordeaux, France*

Contact:
david.tilve@imdea.org

Further reading:
<https://theses.hal.science/tel-04356509>

persion state of the filler. Further, it provides an overview of recent studies on 3D-printed conductive nanocomposites and the 3D printing radar absorber materials by digital light processing, explaining the microwave absorption fundamentals and mechanisms of microwave performance. Then, three chapters present the key experimental steps. The first deals with transparent resins for accurate 3D printing of conductive materials based on neat graphene oxide with high monolayer content, reduced by thermal post-treatment after printing. The chapter describes the formulations, characterisation of their rheological and optical properties and the microstructural, mechanical and electrical properties of the 3D-printed nanocomposites. The next chapter is focused on electrical anisotropy in single-walled carbon-nanotube surfactant-assisted composites. The study revealed that the conductivity anisotropy of up to two orders of magnitude is mainly due to the large contact resistance between 3D-printed layers and probed that is not due to the orientation of the filler. It can be mitigated by a proper choice of process parameters. Finally, to further improve the electrical performance, both types of carbon nanoparticles were combined, with single-walled carbon nanotubes stabilised in an acrylic matrix by graphene oxide. The chapter also compares the dielectric properties of all three composites at microwave frequencies, showing the hybrid one as the most promising candidate for microwave absorbers.

Doctoral thesis – Summary

Author:
Pauline Rothmann-Brumm

Speciality field:
Mechanical Engineering

Supervisors:
Edgar Dörsam
Ilia Roisman
Arjan Kuijper

Defended:
 12 December 2023, Technical
 University of Darmstadt, Department
 of Mechanical Engineering, Institute
 of Printing Science and Technology
 Darmstadt, Germany

Language:
 German

Original title:
*Visualisierung, Analyse und
 Modellierung von fluiddynamischen
 Musterbildungsphänomenen im
 Zylinderspalt unter Anwendung von
 Maschinellem Lernen*

Contact:
rothmann-brumm@idd.tu-darmstadt.de

Further reading:
 DOI: [10.26083/tuprints-00026770](https://doi.org/10.26083/tuprints-00026770)


Visualization, Analysis and Modeling of Fluid Dynamic Pattern Formation Phenomena in the Cylinder Gap Using Machine Learning

This thesis aimed to advance the understanding of fluid dynamic pattern formation phenomena in gravure printing to form a base for further improvement of process control in various industrial printing applications. The comprehensive research brought insight into key factors for achieving comparable results from laboratory and industrial printing machines, processes in the gravure nip, fluid splitting, applicability of machine-learning approaches and predictability of pattern formation.

The text provides an overview of the gravure printing process, areas of its application, and printing forms, inks and substrates used. Further, it describes the fluid splitting modes, pattern formation in the cylinder gap, viscosity and surface tension characterisation and methods for data-driven analysis, which included digital image data processing and feature extraction, fast Fourier transform for frequency analysis, singular value decomposition for modal analysis and machine learning, namely different classification algorithms and deep learning using convolutional neural networks. The experimental work is presented in four chapters, the first of which summarises the findings from the preliminary tests to optimise all the approaches applied in the main part of the work, detailed in the following chapters. As the first step, extensive test series of samples were printed on two industrial gravure presses for different combinations of printing speed, printing inks, viscosity, substrate, doctor blade angle, tone value, screen frequency, and electrostatic printing assist use. Also, a dedicated gravure research platform was developed to acquire high-speed video recordings of the temporal behaviour of printing ink in the gravure nip. The second step involved the classification into point splitting, transition regime and lamella splitting. This was complemented by frequency analysis and qualitative video data analysis, showing the influence of printing speed and screen frequency. The third step comprised the application-based modelling of cause-effect correlations between selected factors and fluid splitting class and the analysis of the finger patterns scaling behaviour. The dissertation also provides links to both raw and processed image datasets and other research data.

Events

NANOTECHNOLOGY 2024

 Thessaloniki, Greece
29 June – 6 July 2024

This long-established international event keeps a scheme combining three conferences and an exhibition on nanotechnologies, organic electronics and nanomedicine, complemented by the business forum and matchmaking event and framed by three days of related summer schools. The 17th International Symposium on Flexible Organic Electronics includes several workshops organised in the scope of numerous EU-funded projects. Their programme offers keynotes, invited lectures and other contributions that share the advances in the areas ranging from organic and large-area electronics materials, organic and perovskite photovoltaics, novel manufacturing strategies of organic light-emitting diodes, organic thin-film transistors and sensor devices, smart textiles, wearables and the Internet of Things, to biosensors and bioelectronics, up to artificial intelligence, machine learning, intelligent manufacturing and automation, in-line and real-time metrology and quality control for nanomanufacturing, computational modelling of materials, devices and processes and open innovation and standardisation approaches.


FLEX 2024

 San Francisco, California, USA
9–11 July 2024

The theme of this edition is additive innovation in flexible hybrid and printed electronics. The keynotes include ‘A vision for next generation intelligent electric systems’ by Ercan M. Dede, ‘Microgravity: a new frontier for next-generation semiconductor materials & electronic fabrication’ by Chyree Batton, ‘Advanced packaging for sustainable additive manufacturing innovations’ by C. P. Hung, and ‘Responsible human/AI collaboration’ by Lama Nachman.

SIGGRAPH 2024

**The 51st International Conference & Exhibition
on Computer Graphics & Interactive Techniques**


 **SIGGRAPH 2024**
DENVER+ 28 JUL – 1 AUG Denver, Colorado, USA
28 July – 1 August 2024

The rich programme of this event continues to encompass the developments in production and animation, research and education, arts and design, gaming and interactivity and new technologies. The announced keynote speakers are Mark Sagar on the work towards the creation of autonomously animated virtual humans, Jensen Huang on artificial intelligence and graphics for the new computing revolution, Dava Newman on advanced space and climate computer graphics, and Manu Prakash on the insight into computing in biological matter. In addition, this year’s edition of the High-Performance Graphics conference is co-hosted with SIGGRAPH from 26 to 28 July.


FLEPS 2024

**6th IEEE International Conference
on Flexible, Printable Sensors
and Systems**

Tampere, Finland
30 June – 3 July 2024

 The schedule of this edition mostly runs in two tracks and combines technical sessions with tutorials and workshops. The plenary speakers are Aaron Thean, discussing low-thermal budget functional materials for enhancing flexible and semiconductor electronics, Jani Kivioja, presenting the solutions for atomic and molecular layer deposition in the flexible electronics industry, and Manos M. Tentzeris, introducing fully integrated printable broadband wireless modules for communication, energy harvesting and sensing.

FuturePrint 2024

 São Paulo, Brazil
10–13 July 2024

The focus of this fair is on visual communication, screen printing and digital textile printing. Its forum covers colour management, outdoor media, personalised products, 3D printing, business management, and more. Also, training in print design and modelling can be joined,

I3S 2024

**10th International Symposium
on Sensor Science**

 Singapore
1–4 August 2024

This year, the symposium is joined with the 1st International Conference on AI Sensors. The event includes the invited talk ‘Printed electronics and sensors for AI healthtech’ and papers presenting other printed solutions.

ICFPE 2024 14th International Conference on Flexible and Printed Electronics

Taipei, Taiwan
28–30 August 2024 

This year's programme offers each day three keynotes, including the one by Takao Someya on 'Recent progress of electronic skins', five tracks of technical sessions and workshops on applications, devices, processes and equipment, materials, and energy, with the additional session organised by OE-A on the first day.

PRINTING United Expo

Las Vegas, Nevada, USA
10–12 September 2024

This show offers the opportunity to explore the trends and developments in all kinds of printing, from commercial and publishing to apparel decoration up to functional and industrial printing, collect samples and other resources and meet industry leaders.



FESPA Events

The September events focused on printing and signage include this year's editions of FESPA Africa (11–13 September in Johannesburg, South Africa), co-located with Africa Print, Modern Marketing and Graphics, Print & Sign, FESPA Eurasia (11–14 September in Istanbul, Turkey), and FESPA Mexico taking place two weeks later (26–28 September in Mexico City).



The Print Show 2024

Birmingham, UK
17–19 September 2024

This UK event features talks on interesting topics, including printing for people with visual impairment and factors important for building print careers.



SPIE Optics & Photonics 2024

SPIE. OPTICS+
PHOTONICS San Diego, California, USA
18–22 August 2024

In 2024, this multidisciplinary event features several conferences on different types of organic and hybrid electronics, invited paper dealing with fast and edible transistors based on organic semiconductors towards applications in biomedicine and food quality monitoring, contributions presenting various applications of 3D printing, e.g. 3D-printed micro-optics and elastomer actuators, and more. The exhibition accompanies the conference for the last three days. A month later (16–19 September), the SPIE Sensors & Imaging event takes place in Edinburgh, UK, and also covers print-related topics.


Advances in Printing Technology 2024

Busan, South Korea
4–6 September 2024



This meeting comprises academic and business sessions and tutorials related to printing. It can also be accessed live online or later. The opening keynote by Toshitaka Uemura focuses on the benefits of digital printing technology beyond the printing process; the closing one by Gyoujin Cho presents the concept of the roll-to-roll gravure foundry for manufacturing flexible and inexpensive (bio)electronic devices. The focal talks cover sustainable and unattended print colour control, appearance reproduction and individual observer profiles, inkjet technology developments to increase sustainability, artificial intelligence patent trends, fully printed nanocomposite, and surface microstructure by additive manufacturing.

50th iarigai and 55th International Circle Conferences

 Zurich, Switzerland
8–11 September 2024

Advances in Printing and Media Technology, the international research conference of iarigai, celebrates its 50th anniversary jointly with the International Circle of Educational Institutes for Graphic Media Technology and Management conference in its 55th year. The contributions deal with bio-based dyes, pigments and inks, additive manufacturing, augmented reality, generative artificial intelligence, model-based data-driven automation, and other topics.

22nd International Coating Science and Technology Symposium

Atlanta, Georgia, USA
8–11 September 2024

In 2024, this event features keynotes on sustainable coating materials by YuanQiao Rao, coating science for fuel cell and electrolyzer manufacturing by Scott Mauger, phase transformations in metal halide perovskites by Juan-Pablo Correa-Baena, coating, drying and post-drying in battery applications by Philip Scharfer and Wilhelm Schabel, and solution-processed perovskite films for scalable solar cells by Jangwon Seo.