# TOPICALITIES

*Edited by Markéta Držková*

CONTENTS

# News & more

## Patents in the area of printed electronics granted since 2024

This overview of recent patents presents a selection of those granted since January 2024 and retrieved for the term "printed electronics". The search returned about 600 patents, of which over a third are U.S. patents and a fifth are Chinese. The other more represented are the Japanese, European and Korean patents (16 %, 11 % and 10 %, respectively). The rest includes, e.g., the Taiwanese, German and Spanish patents. When considering inventions' classifications, the use of additive manufacturing increased compared to the previous summary with this focus, published in JPMTR Vol. 10 No. 1 (2021). Also, more inventions are aimed towards climate change mitigation in energy, production and processing technologies. However, the range of fields and applications covered by the patents from this selection is again wide, and only about a fifth of assignees own more than one patent. The most active and successful ones are presented in the following sections. Other examples are briefly introduced in the side column.

### TactoTek

This company remains outstanding, with about 30 recent patents granted by U.S., European and Asian patent authorities, within the search results for the area in focus. The latest patent, filed in September 2024, is US 12,376,450 B2 Optically functional multilayer structure and related method of manufacture, describing the optoelectronic light sources integrated with the electrical circuit on a flexible 3D-formable thermoplastic film that can internally illuminate the structure for external perception. Other examples of recent TactoTek patents include EP 3 739 497 B1 Arrangement and method for facilitating electronics design in connection with 3d structures, which describes the utilisation of computer-aided design and mapping between the desired 3D structure and 2D circuit design, US 11,914,184 B2 Optically functional multilayer structure suitable for large area illumination and related method of manufacture, which enables dynamic or adaptive illumination control, US 11,950,367 B2 Method for manufacturing electronics assembly, describing the procedure of joining two substrates with circuitry and electronics components, while creating a protective pocket for delicate components, such as a module for wireless communication and an antenna element, and US 12,052,829 B2 Method for manufacturing a number of electrical nodes, electrical node module, electrical node, and multilayer structure, where the electronic circuits are spaced from each other on the substrate and embedded in the potting or casting material, which forms a filler layer after hardening or curing.

### Lyten

This company develops advanced materials with tunable properties, based on a solid carbon material called Lyten 3D Graphene, and their applications in devices, such as batteries and sensors. The recently patented inventions include a split-ring resonator formed from a 3D carbon monolith and embedded within a semi-rigid foam-based material to indicate the state of the material by generating an electromagnetic return signal in response to the electromagnetic ping, where a resonance frequency shift results from a de-

### More on the recent patents on printed electronics

While printed electronics, as such, represent an integral facet of digital transformation, one group of related patents deals with utilising current advanced computing systems for printed electronics design and production. The solution described in US 12,007,746 B2 Methods and systems for enabling and scheduling 3D printing-based fabrication, assigned to the Strong Force Vcn Portfolio 2019, enables integrating 3D-printing processes into the larger manufacturing computing environment and using artificial intelligence to enhance modelling, material selection, scheduling and other tasks. The patent includes an exemplary architecture of a complete printed electronics system, from user input to choice of materials and printing technology, up to a desired output. As a second example, US 11,882,664 B2 Artificial intelligence-assisted printed electronics self-guided optimization method of the Northwestern Polytechnical University considers variables that impact printing quality to streamline testing and finding optimal printing parameters.

Another group of patents deals with materials for printed electronics, such as the ink containing copper nanoparticles or nanowires and suitable, for example, for aerosol jet, inkjet or dispenser printers, described in US 11,987,717 B2 Air-stable conductive ink of The Research Foundation For The State University Of New York, the particle-free metal-complex composition enabling printing elements such as resistive heaters and force or motion sensors and integrated devices, e.g. force responsive conductive heaters, presented in US 11,999,864 B2 Molecular ink and method for printing resistive film coatings of the Liquid X Printed Metals company, and the material comprising carbon

nanotubes functionalised with selected indigo-based compounds for producing printed carbon dioxide sensors and thin-film transistors, reported in US 12,181,431 B2 Indigo-based polymers for use in SWCNTs electronics of the National Research Council Of Canada. Among substrates intended for printed electronics, a joint patent of RAIZ (Forest and Paper Research Institute), The Navigator Company and NOVA University Lisbon, EP 3 872 257 B1 Dual flexible cellulose-based matrix for electronics and microfluidics integration, can be mentioned as an example.

The patents with the focus on applications and devices include the ARM's patent US 11,969,030 B2 Integrity monitoring for flexible material, intended for wearable items and comprising the corresponding circuitry, which can be complemented by a printed battery, triboelectrical energy harvester, organic LED display and component for near-field communication, US 12,003,235 B2 Tactile sensor formed on polyimide thin film having high total light transmittance, and switching device using same of Mitsui Chemicals, ES 3 009 009 T3 of the Porcher Industries company, presenting a printed electronic textile component, and US 12,227,129 B2 Illuminated trim component and method of making of the Inteva Products company, delivering vehicle interior systems. Other applications for vehicle manufacturing are illustrated in US 12,006,018 B2 Aircraft cabin component and method for manufacturing an aircraft cabin component of Airbus Operations, and DE 10 2023 101 372 B3 of Audi, describing an electronic arrangement for a motor vehicle with additively printed conductor tracks, structures and electronic components. Examples of patents for healthcare, besides those of Jabil presented in the main column, include EP 3 454 935 B1 Attenuation arrangement for implantable medical device of Inspire Medical Systems, US 12,214,175 B2 Electronic-ink label for a drug delivery device of Sanofi, and US 12,092,629 B2 Simultaneous disease detection system method and devices, invented by M. Hummer and G. J. Hummer.

formation, stress, or strain of the material, as described in US 11,892,372 B2. This solution can be utilised in components of drones, aircrafts or rockets, and used, for example, for locating a position of the airborne vehicle with respect to a landing pad, as illustrated in US 12,196,636 B2, or incorporated into building materials, e.g. concrete or steel, to indicate their deformation, compression, flexion, fracture, strain or stress compared to the original state in order to increase safety thanks to timely and targeted maintenance, as discussed in US 12,339,272 B2. Yet another applications of split-ring resonators are presented in US 12,025,510 B2 Sensors incorporated into tire plies to detect reversible deformation and/or temperature changes, US 12,270,785 B2 Water droplet sensing systems and methods, in which a resonant frequency reflects fluid accumulation on the material, US 12,174,090 B2 Field deployable resonant sensors, intended for the indication of an exposure to an analyte, a bio-material, or radioactivity, based on a meso-scale or micro-scale resonator on a surface of the flexible matrix with properties changing according to an extent of adsorption, or US 12,265,058 B2 Sensors incorporated into adhesive material, where the adhesive material is a porous flexible matrix comprising chemically reactive components to sense the change in concentration of one or more volatile substances.

## Jabil

A wide range of solutions provided by this global manufacturing company also includes printed electronics, especially textile-integrated electronics and other healthcare applications. Jabil builds on its experience in mobile devices, miniaturisation, sensor integration, 3D printing, connectivity, optics, and cooperation across diverse industries. Among its recently granted patents, US 12,354,780 B2 presents producing flexible planar inductive coils suitable for embedding and, e.g., serving as acoustical, antenna, or inductive coupling coils, and US 12,076,543 B2 describes a conformable heater sensor suitable for association with a fluid bag for intravenous therapy to sense the temperature and also the level of fluid within the bag and send the data to a remote mobile device app using the integrated wireless sender. Another application of a printed heater system is covered by US 12,010,765 B2, which deals with a conformable heater for embedding in wearables, where the heating elements are controlled by the system featuring a wireless receiver that enables setting the amount of generated heat using a mobile device app. Two patents address health and vital signs monitoring using products with integrated display, namely a ring in US 11,857,342 B2, and a patch in US 11,980,467 B2, which can implement an accelerometer, sensors for measuring pH, temperature or an electrocardiogram, as well as the transmission or reflection mode oximetry, and components for processing and transmitting the data. Further, EP 3 718 037 B1 presents a printed functional circuit for authentication and certification, applicable to match a coffee pod and a brewing machine, or a diagnostic cassette and a reader, for example.

## TLB

The recently published patents of this producer of printed circuit boards, based in South Korea, include, for example, KR 10-2808915 B1 Ink composition for plating and manufacturing method of printed circuit board using same, describing the ink formulation comprising a metal catalyst, solvents and a polysiloxane copolymer, to provide an excellent storage stability and rheological properties and improve adhesion between layers of a printed circuit board, and KR 10-2780647 B1 Method for forming pattern using photosintering, which presents manufacturing a fine pattern with a thickness from 1 μm and resistivity of 10 μΩ·cm or less using a metal powder ink.

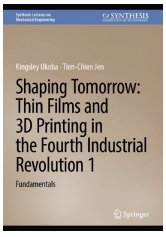
# Bookshelf

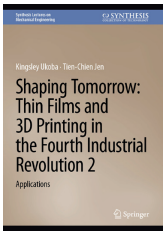
## Shaping Tomorrow: Thin Films and 3D Printing in the Fourth Industrial Revolution
## 1: Fundamentals
## 2: Applications

In these two volumes, the authors review various aspects of Industry 4.0, thin films, and 3D printing, discuss the current trends in these areas, and explore the opportunities and challenges associated with their integration, with a detailed but somewhat repetitive account of existing and emerging innovative solutions in many fields of application.

The content in both volumes is organised into five chapters. The first one introduces the Fourth Industrial Revolution, its evolution, core principles, implications, and use in different sectors from manufacturing to transportation and mobility, along with key drivers and technological enablers of Industry 4.0, comprising Internet of Things, artificial intelligence, big data analytics, cyber-physical systems, additive manufacturing, and cloud computing. It also covers regulatory frameworks and policy considerations. The second chapter describes the history of thin films and their properties, including thickness, uniformity, structural, optical, electrical, mechanical, and chemical characteristics, as well as deposition techniques for fabricating thin films. Further, it discusses emerging trends in thin films, such as nanotechnology integration and advancements in 2D materials, addressing challenges in thin film production and integration, and their role in driving technological innovation, especially in sustainable development. The third chapter introduces 3D printing and the progress in its technology, and presents its benefits for Industry 4.0, including customisation, effective prototyping and opportunities to reduce environmental impact. It also covers applications of 3D printing in different areas and their global impacts and outlook. Two chapters discuss the limitations and possibilities of thin films and 3D printing and their integration.

The second volume is dedicated to applications of thin films in flexible electronics, hydrogen produced using renewable energy sources, battery technologies, solar technology, and high-performance displays and lighting. Besides providing fundamental background for each of these groups, it discusses individual types of thin films made of both commonly used and special materials, their essential properties and important process parameters, advantages they bring and advances and innovations they enable, as well as barriers to their utilisation, issues to be addressed and possible solutions. In addition, it presents real-world examples, case studies, market trends, and emerging and future directions. Among fabrication techniques, besides physical and chemical vapour deposition and other techniques typically classified as slow and high-cost, the text also covers solution-based techniques, including printing, especially inkjet printing, and describes their use in producing organic light-emitting diodes, sensors, batteries, organic photovoltaics and other components and devices on flexible substrates.



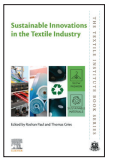




*Authors: Kingsley Ukoba, Tien-Chien Jen*

Publisher: Springer
1st ed., March & April 2025
ISBN: 978-3-031-84123-1 & 978-3-031-88168-8
365 & 356 pages, 23 & 29 images
Hardcover
Available also as an eBook

## Sustainable Innovations in the Textile Industry

*Editors: Roshan Paul, Thomas Gries*



Publisher:
Woodhead Publishing
1st ed., June 2024
ISBN: 978-0323903929
594 pages, Softcover
Also as an eBook

This comprehensive volume in The Textile Institute Book Series intends to support and accelerate the sustainable transformation and ongoing innovation activities. About 50 contributors cover the sustainability aspects of the whole textile chain, including conventional and digital printing, functional finishing, and smart coating.

## Accelerating Digital Transformation with the Cloud and the Internet of Things (IoT)

*Authors: Yacine Atif, Sujith S. Mathew*

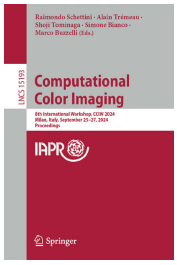
Publisher:
Academic Press
1st ed., January 2025
ISBN: 978-0443222177
444 pages, Softcover
Also as an eBook

This book provides a detailed account of the topic to guide with planning, deploying and running IoT platforms. The first part of this book introduces technologies and concepts of the cloud and IoT ecosystem. It discusses technical challenges and economic opportunities of the cloud-to-things continuum, and presents the IoT cloud platforms, applications and services, as well as data management and lifecycle. It also focuses on enhancing business value, the role of interoperability for sustainable digital transformation, and specific aspects of IoT on the enterprise level. The second part concentrates on IoT cloud security across IoT platform layers, describing how to discover, analyse and mitigate IoT-cloud vulnerabilities, and IoT security best practices. The third part deals with practical aspects of smart citizenship and strategies for implementing digital transformation

## Computational Color Imaging

This volume presents the proceedings of the 8th International Workshop on Computational Color Imaging (Milan, Italy, 25–27 September 2024), which was focused on integrating advanced artificial intelligence algorithms and deep learning models in colour imaging. The book includes 18 papers selected for presentation based on a thorough review, complemented by 2 papers and 1 extended abstract of invited talks.

The contributions are organised into six groups: colour theory and spaces, image enhancement and retinex theory, hyperspectral and spectral imaging, printing and machine-learning applications, perceptual quality, medical imaging and art applications, and colour constancy. The papers deal with the colorimetric approach that considers colours in terms of ranges or probability distributions instead of their point representation, the comparison of perceived differences between pairs of colours on varying backgrounds with measured values, which shows the insufficiency of existing measures of colour difference, image processing to reproduce the perceptual glossiness, dithering with two versions of a cellular automaton as a novel approach to halftoning and improving print quality, and the possibilities of utilising large language models and other generative AI methods to achieve ease of use and automation in print manufacturing, to name a few topics.




*Editors: Raimondo Schettini, Alain Trémeau, Shoji Tominaga, Simone Bianco, Marco Buzzelli*

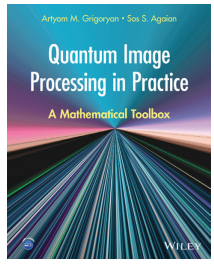
Publisher: Springer
1st ed., October 2024
ISBN: 978-3-031-72844-0
309 pages, 132 images
Softcover
Available also as an eBook

## Quantum Image Processing in Practice
### A Mathematical Toolbox

In this new book, the authors elucidate quantum computing, a probabilistic and parallel approach to computation, promising to overcome performance limitations in image processing. The content includes detailed examples, diagrams, code snippets, and exercises to facilitate understanding.

The first part provides a mathematical foundation of quantum computation, introducing the main concepts of qubits, their matrix and graphical representations, and principles of their use. This includes qubit states, superpositions, measurement, operations and gates, first explained for two-qubit and then for multi-qubit systems, essential for quantum image processing. Further,

*Authors: Artyom M. Grigoryan, Sos S. Agaian*

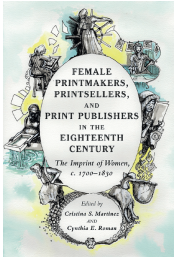



Publisher: Wiley
1st ed., March 2025
ISBN: 978-1-394-26515-2
320 pages
Hardcover
Available also as an eBook

it presents the quantum implementations of fast discrete paired, Fourier, and Hadamard transforms, as well as a novel concept, the quantum discrete signal-induced heap transform. The applications in image processing are described in the second part. It deals with various models of quantum representation for greyscale and colour images in different colour models, with one chapter focusing specifically on the multi-qubit Fourier transform representation, which encodes the image information on the unit circle. Then, it presents new operations of qubits and their use in image summation, linear convolution and filtration, quantum colour image processing using quaternion-based arithmetic, quantum schemes for multiplication of two qubits, and a new quaternion qubit image representation. Finally, it discusses quantum neural networks and their potential applications in image classification, recognition, segmentation, restoration and reconstruction, and concludes with opportunities, challenges and suggestions for further research.

## Female Printmakers, Printsellers, and Print Publishers in the Eighteenth Century
### The Imprint of Women, c. 1700–1830

This book, dedicated "to all women in the print trade", offers new perspectives on their history in a given period, based on new research and the gathered material evidence of various forms. While the first part explores printmaking as a means of self-presentation and self-promotion, the second part presents lesser-known women printmakers working in family workshops. The third part focuses on women in the print publishing and selling business. The title is now also available as an open-access book and in softcover.



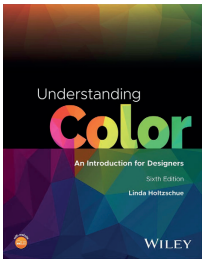

*Editors: Cristina S. Martinez, Cynthia E. Roman*

Publisher: Cambridge University Press
1st ed., March 2024
ISBN: 978-1-108-84477-2
292 pages
Hardcover
Available also as an eBook

## Understanding Color
### An Introduction for Designers

The 5th edition of this successful book, first published more than 30 years ago, was presented in JPMTR Vol. 6, No. 2 (2017). The current edition begins with a chapter discussing the role of colour in design; the chapters introducing light and light sources, colour vision and basic colour-related concepts were reorganised. Again, readers can download the workbook.

*Author: Linda Holtzschue*

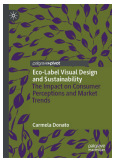



Publisher: Wiley
6th ed., May 2025
ISBN: 978-1-394-18672-3
208 pages
Softcover
Available also as an eBook

with IoT and cloud. It describes real-world examples in healthcare, municipality services, and mobility solutions, discusses their impact, and proposes the investment roadmap.

## Eco-Label Visual Design and Sustainability
### The Impact on Consumer Perceptions and Market Trends

*Author: Carmela Donato*




Publisher:
Palgrave Macmillan
1st ed., February 2025
ISBN: 978-3031827600
130 pages, Hardcover
Also as an eBook

In this book, the author presents her research into eco-label certifications. The book describes an eco-label as a sustainable communication tool and explores the psychology and cognitive mechanisms of aesthetic influence on consumer behaviour. Besides theoretical aspects, the book describes the empirical study on the effect of the visual design of eco-label logos on consumers' sustainability perceptions and discusses its results.

## Perspectives on Design and Digital Communication V
### Research, Innovations and Best Practices

*Editors: Daniel Brandão, Nuno Martins, Emilia Duarte*

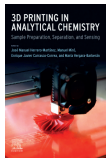

Publisher: Springer
1st ed., December 2024
ISBN: 978-3031761553
415 pages, 159 images
Hardcover
Also as an eBook

This volume comprises invited chapters and original contributions based on the best papers from the 7th International Conference on Digital Design and Communication. The topics include, for example, flexible visual identity systems, exploring behavioural dynamics in sans-serif fonts through eye-tracking, and advancements in prompting text-to-image models for logo design.

## 3D Printing in Analytical Chemistry
### Sample Preparation, Separation, and Sensing

*Editors: José M. Herrero Martínez, Manuel Miró, Enrique J. Carrasco-Correa, María Vergara-Barberán*

Publisher: Elsevier
1st ed., January 2025
ISBN: 978-0443156755
498 pages
Softcover
Also as an eBook

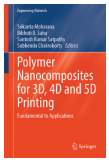



This comprehensive reference, contributed by over 50 experts, covers the key aspects of 3D printing in the context of its utilisation in analytical chemistry. The content is organised into five parts. The first introduces relevant 3D-printing technologies and materials, the fabrication of 3D-printing devices for analytical applications, and 3D printing of analytical platforms. The following three parts provide a detailed account of 3D printing in analytical sample preparation and separation techniques, as well as 3D-printing devices for sensing and biosensing applications. The last section offers the outlook of 3D printing in analytical chemistry based on an analysis of a hundred randomly selected research articles.

## Polymer Nanocomposites for 3D, 4D and 5D Printing
### Fundamental to Applications

*Editors: Srikanta Moharana, Bibhuti B. Sahu, Santosh K. Satpathy, Subhendu Chakroborty*

Publisher: Springer
1st ed., May 2025
ISBN: 978-9819642137
561 pages, 160 images
Hardcover
Also as an eBook




This book, with over 50 contributors, provides an overview of advanced additive manufacturing techniques and the main types of polymer nanocomposites, describing their use to enhance material properties and device performance in numerous applications in various fields.

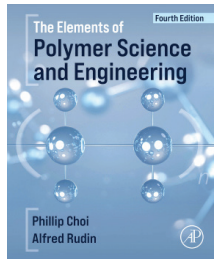
## The Elements of Polymer Science and Engineering

This textbook provides the essential background on polymers, from the basic definitions, concepts and classification of polymers, molecular weight averages and distribution and different methods for their measurement, to fundamental polymerisation principles main polymerisation and copolymerisation types, important properties of polymers, including dynamic behaviour, and diffusion in polymers, up to natural polymers and bio-based polymers, blends and composites.

The current edition includes new and updated coverage of multifunctional and bio-derived polymers, polymer sustainability, and newer manufacturing methods like 3D printing. The progress in characterisation methods, understanding the structure–property relationships of various polymer types and tailoring macromolecular structures, which was made from the third edition, published dozen years ago, is reflected in three new chapters dealing with controlled radical polymerisation methods based on atom transfer or reversible addition/fragmentation chain transfer polymerisation, polymer conformations and theoretical models for calculating chain dimensions, and thin polymer films adsorbed on or tethered to surfaces. Also, to make the book more comprehensible, the chapters are reorganised and in part rewritten, with additional numerical examples, figures, practice problems, and derivations illustrating the influence of different variables in key equations.

*Authors: Alfred Rudin, Phillip Choi*

Publisher: Academic Press
4th ed., April 2025
ISBN: 978-0-323-90649-4
608 pages
Softcover
Available also as an eBook




## Micro Electromechanical Systems (MEMS)
### Practical Lab Manual

This practical guidebook covers the whole range of experimental procedures relevant to micro-electromechanical systems and devices. Two chapters deal with multiphysics numerical simulations and modelling. The next five chapters describe the fabrication methods, including two 3D-printing techniques, stereolithography and fused deposition modelling, along with the corresponding design considerations, materials, instrumentation and software, and individual fabrication steps. Then, two chapters present the methods for morphological and spectroscopic characterisation, and the last three are dedicated to examples of microfluidic, wearable and energy devices.

*Editor: Sanket Goel*

Publisher: Wiley-IEEE Press
1st ed., January 2025
ISBN: 978-1-394-22983-3
208 pages
Hardcover
Available also as an eBook

# Bookshelf

## Academic dissertations

### Analysing the Effects of 3D Printing Defects and Surface Roughness on the Properties of Acoustic Materials

Doctoral thesis – Summary

Author:
*Agnieszka Helena Ciochon*

Speciality field:
*Mechanical and Manufacturing Engineering*

Supervisor:
*John Kennedy*

Defended:
*26 October 2023, Trinity College Dublin, Department of Mechanical, Manufacturing & Biomedical Engineering*
*Dublin, Ireland*

Contact:
*aciochon@tcd.ie*

This thesis investigated a specific aspect of additive manufacturing, namely the acoustic performance of 3D-printed periodic materials. The systematic approach consisted of several stages: manufacturing a benchmark geometry using fused deposition modelling, masked stereolithography and selective laser melting, non-destructive testing of produced samples, using obtained surface profiles to create realistic computational geometries and refine the numerical model that initially assumed smooth surface finish, proposing an enhanced unit cell designs with rough computational geometries resembling extrusion-based 3D printing and their production using photopolymerisation-based technology, optimising unit cell and designing a new acoustic material solution, producing the resulting design by fused deposition modelling and verifying its function.

The introduction presents the research area and related concepts, including the benchmark cell geometry proposed within the European COST action DENORMS (Designs for Noise Reducing Materials and Structures). The next two chapters present the theory, especially on porous and resonant sound absorbing materials, additive manufacturing technologies based on extrusion, photopolymerisation and powder-bed fusion, 3D-printing defects in terms of product surface roughness and limited dimensional accuracy, as well as material microporosity, and their effect on acoustics. Four experimental chapters describe additive manufacturing of samples using the three different technologies, their assessment using digital and confocal microscopy, computed tomography scanning and acoustic evaluation, exploring the possibility of considering surface roughness in numerical modelling of the acoustic performance, and implementing the findings in surface roughness design and example application of 3D-printed acoustic material enhancing the low-frequency behaviour of a commercial acoustic silencer.

Further reading:
*http://hdl.handle.net/2262/104245*

### Stretchable Electronics Using Wood-Based Functional Materials

Doctoral thesis – Summary

Author:
*Mohsen Mohammadi*

Speciality field:
*Organic Electronics*

Supervisors:
*Klas Tybrandt*
*Magnus Berggren*

Defended:
*14 May 2024, Linköping University, Department of Science and Technology*
*Norrköping, Sweden*

Contact:
*mohsen.mohammadi@liu.se*

The research within this thesis contributes to the development of stretchable electronics by addressing their common limitations while also considering environmental impacts. In particular, the work explored the utilisation of wood-based functional materials in novel designs of soft electromagnetic actuators, strain sensors, conductors, and energy storage devices and their integration for several example applications. The conductive foam based on cellulose nanofibrils was employed to add a strain-sensing functionality to a stretchable and compressible ultrasoft electromagnetic actuator composed of multiple ring coils and an integrated ring magnet, allowing operation without an external magnetic field, and to a fully soft electromagnetic vibrotactile device with spiral coils made by direct laser ablation of stretchable conductive composites. Further, the lignin-based sacrificial mask biocomposite was used for high-resolution laser patterning with high aspect ratio to form ultrasoft and stretchable conductors for multilayer stretchable printed circuit boards with integrated rigid components. Finally, the lignin-based active material was utilised in a fluid-based organic battery.

The first part of the dissertation introduces the scope and aim of the thesis. The second part provides the background on properties and principles important for stretchable electronics, together with suitable types of materials and patterning methods, the properties of cellulose nanofibrils and lignin relevant for their possible applications in stretchable electronics, and the architectures and fabrication approaches for the investigated devices comprising stretchable printed circuit boards, fluid-based batteries, soft electromagnetic actuators and sensors. The third part presents sacrificial moulding, shear mixing and freeze drying as the implemented fabrication methods, and the characterisation methods, which included optical and scanning electron microscopy, optical profilometry, stretching and compression setups for mechanical and electromechanical measurements, electrochemical impedance spectroscopy, cyclic voltammetry and galvanostatic charge/discharge method for electrochemical characterisation, and force generation measurement and haptic vibration detection for actuator characterisation. The closing parts bring a summary of conclusions for the four papers contained and directions for further research.

Further reading:
*DOI: 10.3384/9789180755887*

Doctoral thesis – Summary

Author:
*Tobias Enk*

Speciality field:
*Media Engineering*

Supervisors:
*Peter Urban*
*Ulrich Jung*

Defended:
*21 November 2024, University of Wuppertal, School of Electrical, Information and Media Engineering Wuppertal, Germany*

Language:
*German*

Original title:
*Orts-Frequenzanalytische Untersuchung analoger Informationsübertragungsvorgänge in Rolle-zu-Rolle Prozessen: zur kausalen Ursachenrückverfolgung von Prozessstörungen entlang der Wertschöpfungskette am Beispiel von Bahnlauf- und Registerschwankungen im Verpackungstiefdruck*

Contact:
*tobias.enk@jagenberg-digital.com*

## Spatial-Frequency Analysis of Analog Information Transfer in Roll-To-Roll Processes: For Causal Root Cause Analysis of Process Disturbances Along the Value Chain, Exemplified by Web Run and Register Fluctuations in Gravure Packaging Printing

The aim of this thesis was to gain an understanding of the underlying causes of the web run and consequently register problems in gravure presses, which still occur despite the advances in engineering and control. Although the accurate register is essential for quality printing of colour content as well as printed electronics, and the misregistration implies considerable waste of time and resources, the existing examination methods used in the industry do not provide sufficient insight into all relevant process factors and their relationships, needed for effective prevention. This work successfully applied an unconventional approach to systematically analyse disturbances causing variations in web run and register, and identify their causes along the process chain. The method employs the analogy between a general communication system and the analogue information transfer process in a roll-to-roll value chain.

The dissertation provides a comprehensive account of the situation and obstacles among all stakeholders, along with technical challenges and the lack of an appropriate theoretical background, which all hinder effective information collecting, sharing, analysing, and interpreting. After defining the objectives, it describes the value chain from paper production to roll transport and intermediate storage, up to roll-to-roll printing process, analogue information transmission fundamentals, a substrate as a material analogue information carrier, and time-frequency analysis for monitoring process disturbances in printing, including disturbances in the slitting section causing web edge variations, vibrations in the drum winder, uneven winding, web running disturbances, and register fluctuations. Then, it presents the overall approach, the whole dataset collected for a specific web-fed gravure printing press, data exploration and preprocessing, resulting transmission channels, spatial-frequency spectrogram visualisation and interpretation for web edge data as an example, and modelling of individual radial, lateral and tangential disturbances. Finally, the work applies the proposed approach to experimental data and discusses the results for web edge disturbances, material-induced and externally induced web run disturbances, and register disturbances.

Further reading:
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# Events

## 51st iarigai and 56th International Circle Conferences

Pardubice, Czech Republic
2–5 September 2025

The joint event of the 51st International Research Conference of iarigai 'AI and robotics changing graphic arts' and the 56th Conference of the IC 'Steps towards new initiatives in print-media education, technology and economics' is hosted by the Department of Graphic Arts and Photophysics at the University of Pardubice. Among the keynotes, Tomáš Těthal reveals 'Ultra-high-resolution printing for industrial and bio applications', Ladislav Hurdálek outlines 'Trends, strategies and materials in packaging', and three speakers share industry insights on implementing AI, automation and digitalisation and their impact. The contributions deal, among others, with the nip pressure variation, wetting behaviour control, sustainability studies and strategies, new possibilities in prepress, various facets of digital transformation in the printing industry, and effective educational approaches.

This year, the conference also hosts the live final of the global iarigai/IC Charity Cloud Printing Competition for printing technology students, where the best two will produce packaging jobs on Cloud Sinapse Flexo simulators.

## NAPIM 2025 Annual Convention and Technical Conference

Charlotte, North Carolina USA
8–11 September 2025

The 2025 topics of this event for the ink industry, organised by the National Association of Printing Ink Manufacturers, include assessing readiness to adopt artificial intelligence in enterprise, real-world AI applications and AI implementation strategies to achieve immediate impact, digital printing technology developments in packaging, brands' perspective on colour, a novel solvent-free, degradable resin for vat photopolymerisation, and more.

## ICFPE 2025
## 15th International Conference on Flexible and Printed Electronics

Tokyo, Japan
17–19 September 2025

This year's edition of this established Eastern Asia event is hosted by the Institute of Science Tokyo. The programme features plenary talks 'Sustainable high-throughput foundry for sticker-like computer via roll-to-roll gravure printing system' by Gyoujin Cho, 'Software defined functions – opportunities for printed electronics' by Alain Schumacher, and 'Electronic structure and molecular orientation of amorphous organic films studied by UV photoemission spectroscopy and Kelvin probe' by Hisao Ishii, and regular and special sessions, including the OE-A session, running in two or three tracks.

## XX Color Conference

Naples, Italy
4–5 September 2025

The 20th edition of this conference comprises two days, each with plenary talks in the morning and the following sessions split into tracks in English and Italian. The presentations include the invited talk on colour features detection using artificial intelligence and contributions presenting the comparative study of color difference measures on textiles with respect to surface topography, a spectral perspective on natural and synthetic dyes, apparent contrast importance for accessibility and limits and potential of current automatic tools for its evaluation, hue cancellation experiments and the quantum perceptual colour space, to name a few.

## AWA & AIPIA Smart Labeling Seminar 2025

Barcelona, Spain
14–15 September 2025

This event, organised by Alexander Watson Associates and the Active & Intelligent Packaging Industry Association, is co-located with Labelexpo Europe 2025, taking place on 16–19 September.

## SPIE Sensors & Imaging 2025

Madrid, Spain
15–18 September 2025

The topics presented at this event include, among others, printed nematic liquid crystal patterns on metal salt-based reactive substrates for zero-power, optical $H_2S$ gas sensors, and 3D-printed multiscale structured devices.

## FTA Technical Conference

Orlando, Florida USA
21–23 September 2025

This FTA's event offers training and certification based on the FIRST specifications and the team competition in flexographic skills on the first morning. The main programme highlights the key trends in flexography, practical aspects of integrating smart features into packaging, and data-driven operation.

## FachPack 2025

Nuremberg, Germany
23–25 September 2025

The visitors of this packaging fair can also attend lectures discussing, for example, minimalism in packaging printing, timely identification of late effects and side effects for optimal packaging minimisation, innovative co-binders for deinking, and research in the field of recycling printed and colored food packaging.

## Luxe Pack Monaco

Monaco
29 September to 1 October 2025

Many topics discussed at this event focus on sustainability, e.g. ultra-lightweight papers with good printability and biodegradable labels.

## 4th International Circular Packaging Conference

Ljubljana, Slovenia
16–17 October 2025

For the fourth time, this conference provides expert insights into recyclable paper packaging, bioplastics, mono-material solutions, cardboard innovations towards circularity, and more.

## American Printing History Association Annual Conference

San Francisco, California, USA
23–25 October 2025

ENDURING IMPRESSIONS
*Private Presses & Their Legacies*
American Printing History Association Conference
San Francisco, Calif., October 23–25, 2025

This traditional event, celebrating printing history, again offers invited talks, paper presentations and panel discussions combined with the handpress printing workshop and tours, for example, to the Letterform Archive and American Bookbinders Museum. In his opening talk, Alastair Johnston unveils the impact of small and fine presses on the culture of California. In the closing talk 'Bound together: printing community and identity in contemporary bookmaking', Amelia Grounds and Kate Laster build on their experience and share insights into a flourishing book community. Other topics for this year's edition include, among others, the comparative analysis of the private presses at the turn of the 20th century in San Francisco, the private press work of Rudolf Koch, Gotthard de Beauclair, and Hermann Zapf, anarchist printshop praxis, and the recovery of traditional techniques and craftsmanship.

## RadTech Europe 2025

Warsaw, Poland
27–29 October 2025

The technical sessions of this two-day event fill three tracks; on the first day, they are complemented by the fourth one with educational sessions, which introduce the basic concepts and provide the background on raw materials, chemistry, formulation, curing equipment and manufacturing. The contributions deal with novel water-based inkjet inks for UV LED curing, water-based resins for excimer UV curing and properties of resulting coatings, research on new photoinitiators, sensitisers and monomers, biocompatible ink formulations, novel materials for two-photon polymerisation, optimisation of wetting properties, adhesion and mechanical properties of radiation-curable inks, potential of UVC LED curing in ink systems, migration testing challenges, deinkability of UV prints, closed-loop inline control systems for UV curing processes, implementing the Internet of Things, Industry 4.0 and artificial intelligence and which process parameters should be monitored and controlled, and more topics.

## OLEDs World Summit

Seoul, Korea
28–29 October 2025

This established Smithers' event for lighting and display innovations is co-located with the Phosphors & Quantum Dots Industry Forum, taking place on the same days, and Image Sensors Asia on 30–31 October; all are held as hybrid events. The agenda of the OLEDs World Summit features presentations discussing the challenges of the large-area nanoscale uniform fabrication of quantum-dot light-emitting diode displays using solution-based processes, the progress achieved in inkjet printing organic light-emitting diode displays, inkjet-printable nanocomposite formulations with high refractive indices and transparency, and other developments.