



SEPTEMBER 8-11
LGP2, GRENABLE

BOOK OF ABSTRACTS



AN EVENT ORGANISED WITH THE SUPPORT OF



Sustainable Printed Circuit Board Technology – Paper-Based PCBs and Beyond

Gerhard Domann

Fraunhofer ISC

Abstract

In recent years, printed circuit board (PCB) manufacturers have shown increasing interest in sustainable technologies. A major challenge remains the poor recyclability of the widely used substrate material FR4. In addition to efforts aimed at improving the recyclability of polymer-based substrates, alternative material approaches such as flax, wood, and paper are being investigated.

The EU-funded CircEl-Paper project explores the potential of paper as a core material for PCB manufacturing. On the one hand, the compatibility of paper substrates with conventional PCB fabrication processes has been evaluated. On the other hand, paper exhibits unique properties that conventional FR4 cannot provide, including suitability for roll-to-roll (R2R) processing and printing.

In this contribution, we present key findings on the performance of paper-based PCBs, highlighting both promising results and existing limitations. Furthermore, we discuss recyclability aspects and assess the potential of paper substrates to contribute to more sustainable electronics manufacturing.

Inorganic piezoelectric screen-printed layers for MicroElectroMechanicalSystems (MEMS): solutions to reduce the environment footprint

Nadia Bencharef^{1,2}, Christopher Castro^{1,2}, Bernard Plano¹, U-Chan Chung², Catherine Elissalde¹, Joana Pimenta³,
Hélène Debéda¹

¹ Univ. Bordeaux, CNRS, Bordeaux INP, IMS, UMR 5218 F-33405 Talence Cedex, France

²Univ. Bordeaux, CNRS, Bordeaux INP, ICMCB, UMR 5026, F-33600 Pessac, France

³CENTI, Ctr. for Nanotechnology and Smart Materials, Famalicao, Portugal

helene.debeda@ims-bordeaux.fr

Abstract

The scientific community is increasingly seeking to reduce the environmental impact of electronic manufacturing processes, whether in terms of the manufacturing stages, their energy consumption and/ or in the choice of materials. Printed electronics have always appealed to manufacturers and particularly the screen-printing technique as it enables both prototyping and mass production of components. Here, we are focusing on a fully printed piezoelectric component for vibration energy harvesting. It is composed of a metallic stainless-steel cantilever with a piezoelectric ceramic layer in sandwich between electrodes. Using Spark Plasma Sintering (SPS) with a specifically designed mold to finely control the applied pressure, it is possible to sinter in a single step ceramic thick films in a short time (<5 min) and at lower temperature (<600 °C) than by conventional sintering (>850 °C). Combining this innovating SPS approach with the development of a green water-based ink, we have successfully produced a multilayer structure based on lead-free piezoelectric material ($\text{K}_{0.5}\text{Na}_{0.5}\text{NbO}_3$) without dopants which exhibits promising dielectric properties, indicative of adequate microstructure and interface quality with regards to the electrodes.

Towards Smarter Everyday objects and structural materials: Integration of Strain and Temperature Sensors via Transfer Printing methods

Rafika Selmi^{1*}, Maëlle Reigner¹, Cheng-Yao Lo², Yu-Wen Chen², Jean Charles Fustec¹, France Le Bihan¹, Maxime Harnois¹

¹ Institut d'Électronique et des Technologies du Numérique (IETR), UMR CNRS 6164, 35000 Rennes, France.

²Department of Power Mechanical Engineering, National Tsing Hua University, Hsinchu 300044, Taiwan

rafika.selmi@univ-rennes.fr

Abstract

This paper presents two transfer printing technologies for the integration of sensors on 3D objects with complex geometries, and materials exhibiting complex properties, such as composite. The main objective is to maximize sensor conformability while minimizing intrusiveness during the measurement of physical parameters, including temperature and strain. The first approach combines screen printing of sensors on a water-soluble polyvinyl alcohol (PVA) film to water transfer printing (WTP) method. The second approach relies on the direct transfer of printed sensors on glass fiber-reinforced epoxy composites.

By integrating low-cost, large-area screen-printing technique with transfer printing strategies, the proposed approaches open new opportunities for sensor integration on natural, composite, and bio-based substrates paving the way for new functionalities that are better adapted to environmental and industrial applications, and ultimately contributing to the development of sustainable systems.

Screen-printed conductive system on fabrics for wearable electronics applications

Olga Rac-Rumijowska

Wrocław University of Science and Technology, Faculty of Electronics, Photonics and Microsystems

olga.rac-rumijowska@pwr.edu.pl

Abstract

The rapid development of wearable electronics has increased interest in the integration of electronic circuits directly into textile materials. One of the major challenges in textronics is the fabrication of conductive structures with suitable electrical and mechanical properties while maintaining high durability and user comfort. This study investigates the influence of smoothing and protective dielectric layers on conductive screen-printed structures deposited on textile substrates. Test structures were fabricated using different configurations of functional layers, including conductive prints applied directly onto fabrics, prints deposited on smoothing layers, and structures additionally protected with encapsulating layers. The electrical properties of the samples, particularly sheet resistance, were analysed together with the morphology of the printed layers using microscopic observations.

The results demonstrated that intermediate dielectric layers significantly improve the quality and uniformity of conductive prints. The best electrical performance was achieved for structures containing both smoothing and protective layers, which reduced the penetration of conductive paste into the textile structure and improved the continuity of conductive paths. The type of textile substrate was also found to strongly affect print quality. Dense PET fabrics enabled the formation of continuous conductive layers with fewer printed layers compared with more porous cotton fabrics.

Although partial penetration of conductive paste into the textile structure improved adhesion, excessive absorption negatively affected electrical performance and complicated the control of functional layer thickness. The obtained results confirm that the proper selection of dielectric layers and screen-printing parameters is essential for the development of reliable textronic systems intended for applications such as textile sensors, frequency-selective surfaces (FSS), thermoelectric generators, and next-generation smart clothing.

Leveraging Printed Electronics for Sustainable Product Innovation at Tageos

Victor Thénot

TAGEOS

Abstract

By harnessing cutting-edge advancements in printed electronics, the Tageos Innovation Center of Excellence is shaping the future of its specialty RFID and BLE inlay portfolio with the integration of innovative materials and scalable manufacturing processes. Beyond enabling highly functional inlays and sensor tags, printed electronics plays a key role in reducing the environmental footprint of electronic products through additive manufacturing, improved material efficiency, and the use of more sustainable substrates.

In this keynote, Tageos will share its innovation approach of how printed electronics can deliver tangible environmental and business value across industries. The presentation will highlight how design choices in materials, architectures and processes directly impact product sustainability. This includes innovations such as replacing costly silver inks with copper-based alternatives, using stretchable and flexible inks and developing inlay products based on recyclable or renewable substrates. A special focus will be given to paper-based RFID inlays, illustrating how printed electronics can enable high-performance products while significantly reducing material usage and environmental impact. Finally, Tageos will outline the reduced carbon footprint of its portfolio, demonstrating how printed electronics can act as a powerful enabler for more sustainable electronics at scale.

Additive Manufacturing of High-Frequency Radiating Devices on Flexible Substrates: From Conformal Electronics to Thermoformed 3D Structures

Thibault Boisseau^{1*}, Marceau Bouchez¹, T. V. Dinh², Sidina Wane², David González Ovejero¹, Maxime Harnois¹.

¹CNRS, Institut d'Electronique et des Technologies du Numérique (IETR), UMR 6164, 35000 Rennes, France.

²eV Technologies, Bâtiment 5, 2 esp. Anton Philips 14 460 COLOMBELLES, France

thibault.boisseau@univ-rennes.fr

Abstract

Printed electronics by additive manufacturing enables the fabrication of high-frequency devices on flexible and complex substrates. This work experimentally demonstrates two complementary approaches. First, high-frequency lines are screen-printed on a planar polypropylene (PP) flexible substrate, showing that functional radiating structures can be produced for developable three-dimensional applications. Measurements on the flat substrate confirm the quality and repeatability of the printed lines.

Second, metasurface antenna patterns are printed and thermoformed onto developable three-dimensional surfaces, demonstrating that printed patterns can adapt to curved geometries while maintaining structural integrity. Although experimental characterization of the thermoformed devices is not yet available, the fabrication process validates the compatibility of screen printing with thermoforming for flexible substrates. These results highlight the importance of choosing the appropriate substrate and fabrication method according to the target geometry, providing practical guidance for implementing printed high-frequency electronics in both non-developable and developable 3D applications.

Embedding Conductive Paths into 3D Objects by Coupling Fused Filament Deposition and Conductive Ink Piezo-Jetting

Yiting Wang, Andrea Graziano, **Davide Beneventi***

Univ. Grenoble Alpes, CNRS, Grenoble-INP (Institute of Engineering Univ. Grenoble Alpes), LGP2, Grenoble, France.

davide.beneventi@pagora.grenoble-inp.fr

Abstract

This work investigates the integration of fused filament fabrication (FFF) 3D printing and piezo-jetting of conductive silver ink using a 6-axis industrial robot, with the aim of embedding functional electronic circuits directly into 3D-printed polymer objects. Planar substrates made from four thermoplastic materials: acrylonitrile-butadiene-styrene (ABS), polylactic acid (PLA), polyethylene terephthalate glycol (PETG), and high-performance PLA (PLA-HT), were characterized with a high-speed laser profilometer to assess the influence of layer height and extruder multiplier on surface roughness. A U-shaped channel design with a small interconnect hole was adopted to route conductive ink between vertically stacked layers. Silver ink (Henkel Loctite Edag 418SS) was deposited by the robot-mounted piezo-jetting printhead into the channels and onto the cover-layer surfaces. Electrical resistance measurements confirmed track conductivity and the effects of channel geometry, layer count, and filament orientation on ink connectivity were systematically investigated. A layer height of 0.15 mm and an extruder multiplier of 103–105 % yield the best surface quality for ABS and PLA. Ink deposited in channels with 0.2 mm layer height gave resistance per unit length of 0.43–0.48 Ohm/cm, in good agreement with theory. Electrical continuity between substrate and cover layers was maintained for stacks of up to four cover layers using a three-pass jetting strategy over the interlayer connecting hole thus demonstrating that the developed approach could be viable for the fabrication of multilayer circuits.

Towards Scalable 3D Microfabrication: Multi-Nozzle Electrohydrodynamic Printing of Ceramic Inks

Yajiao Yang¹, Marco Hölzle², Cornelia Nef², Fritz Bircher¹

¹*Inspire AG, Zurich, Switzerland*

²*Institute for Microtechnology and Photonics, OST University of Applied Sciences, Buchs SG, Switzerland*

fritz.bircher@inspire.ch; yajiao.yang@inspire.ch

Abstract

The fabrication of micro- and nano-scale structures is increasingly important for applications such as printed electronics, sensors, biomedical devices, optical components, and functional surfaces, where device performance strongly depends on feature size and spatial accuracy. Electrohydrodynamic (EHD) printing has emerged as a promising high-resolution additive manufacturing technique that employs electric fields to drive ink ejection, enabling droplet and jet sizes significantly smaller than the nozzle diameter while retaining the flexibility and material compatibility of printing-based processes. In this work, EHD printing is extended toward high- aspect-ratio three-dimensional microfabrication using multi-nozzle printheads to improve productivity. For this feasibility study, a submicron particle-based ceramic ink was used. By tuning the waveform with the EHD printhead driver, a stable droplet ejection was achieved at applied voltages between 1000 and 1200 V. Printing experiments were conducted on a printer from Notion Systems equipped with Scriona Gen 3-8 multi-nozzle printheads. The printed structures were deposited on indium tin oxide (ITO) coated glass substrates and characterized using optical microscopy and confocal surface topography measurements. Three-dimensional patterned structures were successfully fabricated via layer-by-layer deposition, achieving a feature size (resolution) of 10 μm and heights of up to 6 mm. The use of multi-nozzle printing significantly reduced fabrication time while maintaining stable jetting behaviour and high printing quality, demonstrating the potential of multi-nozzle EHD printing as a scalable approach for high-resolution three-dimensional microfabrication

Printed electronics for healthcare: challenges and prospects

Dany Capitaó

Print'up Institute

Abstract

Increasing life expectancy, the rising prevalence of chronic diseases, significant economic pressures on healthcare systems, and the growth of telemedicine are driving a rising demand for medical devices that are both minimally invasive and personalized, enabling continuous patient monitoring. Healthcare-focused printed electronics enable the design of a new generation of sensors that are lightweight, conformable, and custom-made, while remaining economically viable.

In the first section, we will compare printed electronics with conventional electronics, describing current processes and their limitations while highlighting the advantages of this sector in terms of production, environmental impact, and economics.

Next, we will discuss progress made to date, providing a brief overview of devices currently on the market or under development, as well as potential clinical applications—particularly thanks to artificial intelligence.

Finally, we will address the challenges that must be overcome in designing the sensors of the future; these require various approaches spanning chemistry, industrialization, and regulation to ensure patient safety

3D structures by spark plasma sintering with compliant binder jetted salt moulds

Anja Rusch⁴, Andreas Brändle³, Severin Broch³, Visnusuthan Vairavipillai², Eric Wälti², Nicole Kleger⁵, Konrad Papis¹, Fritz Bircher¹

¹ inspire AG, Switzerland

²Advanced Manufacturing Laboratory, ETH Zurich, Switzerland

³Institute of Machine Tools and Manufacturing (IWF), ETH Zurich, Switzerland

⁴Complex Materials Laboratory, ETH Zurich, Switzerland

⁵Sallea (start-up company from ETHZ), Switzerland

Abstract

Additive manufacturing poses challenges for metal composites, hard materials, and some other materials. Here, a 3D printing process is reported for shaping materials into intricate geometries without the need for their printability but instead using 3D printed structures as leachable moulds for near-net-shaping by sintering under geometric constraints. To prove the principal feasibility of such an approach, salt moulds are printed using a binder jetting process with NaCl powder and water-based binders. The moulds are infiltrated with aluminium alloy powder and co-sintered by spark plasma sintering, a fast-sintering technology. The salt moulds are then washed out with water creating finally complex-shaped architectures. The co-sintering process has already been demonstrated in earlier work, employing a different mould manufacturing process.

The reported work focuses on the manufacturing of the moulds as green parts. Several powder compositions combined with several binder formulations have been investigated to find the best combination providing enough stability of the salt mould. To further improve the binder jetting of salt, an active drying system has been integrated into the binder jetting system to dry the bonded layers, thereby increasing stability during the binder jetting process and preventing unwanted diffusion of the binder into the powder bed. In addition, a new recoating blade has been developed that allows finer salt powders and bimodal powders to be processed with improved powder layer quality. The feasibility of the full process chain and the cost-effective and sustainable nature of this new 3D printing process was demonstrated.

100 % bio-based 5-(hydroxymethyl)furfural (HMF) and lignin polymers for Liquid Deposition Modelling (LDM) 3D printing

Eliott Bonnet Martin^{1,2}, Michael Lecourt², Davide Beneventi¹, Aurore Denneulin¹.

¹LGP2 Laboratoire de génie des procédés pour la bioraffinerie, les matériaux bio-sourcés et l'impression fonctionnelle

²Institut technologique FCBA

*eliott.bonnetmartin@fcba.fr; michael.lecourt@fcba.fr; davide.beneventi@pagora.grenoble-inp.fr;
aurore.denneulin@grenoble-inp.fr*

Abstract

This extended abstract presents the development of novel bio-based non-toxic thermosetting polymers and their implementation in liquid deposition modelling (LDM). Lignin-HMF polymers were investigated. Lignin is a phenolic biobased compound derived as a coproduct of the papermaking process with a global production of around 50 million tons a year, most of which is currently burned for energy. The search to valorise this biproduct is of current importance. If lignin is combined with a bio-based aldehyde, such as HMF, it is possible to produce a bio-based thermosetting polymer with excellent thermal stability. Attention is given to the effect of the HMF/lignin ratio on the thermal properties of the resulting polymers, as well as on their processability in LDM. The results of neat resin characterization will be reported. With addition of fillers LDM printing has been successfully carried out, and the first results are shown.

Feasibility of Additively Manufactured ABS-GF and mSLA Resin Embossing Dies for use in Commercial Print Finishing Processes

Lee Eldridge

Media & Design Innovation, The Creative School, Toronto Metropolitan University, 350 Victoria St., Toronto, Ontario, M5B 2K3 Canada

lee.eldridge@torontomu.ca

Abstract

Embossing remains an important finishing process in commercial print and packaging, but the dies used to produce it are typically made from brass, copper, or magnesium through specialized subtractive or etching workflows. These conventional dies remain effective, yet they are often poorly matched to contemporary production conditions shaped by short runs, versioning, rapid revision, and the need for physical prototypes. This study evaluates whether two digitally fabricated alternatives, fused deposition modelling (FDM) using glass-fibre reinforced acrylonitrile butadiene styrene (ABS-GF), and masked stereolithography (mSLA) using an ABS-like resin, can serve as viable substitutes for selected embossing applications.

The paper combines published literature on additively manufactured embossing tools with production testing conducted at two commercial print facilities. Three die types were compared: ABS-GF FDM, ABS-like resin mSLA, and a conventional brass die control. Testing was carried out on three paper stocks: Husky 60# Text (89 GSM), Cougar 80# Text (118 GSM), and Cougar 130# Cover (352 GSM). Across runs of several hundred sheets per stock and die combination, all three die types produced commercially comparable embossing results. Visual inspection on press and macro photographic examination found no meaningful difference in emboss quality, edge definition, or feature retention between the printed dies and the brass control. Post-run inspection also showed no visible wear, rounding, chipping, or breakdown of the printed dies after runs of up to 400 sheets. Operator feedback suggested that make-ready was generally within the range of a conventional cold emboss process, although the heavier cover stock required somewhat more setup time at one site because the printed dies could not be used with the heat-assisted adjustments available in a conventional metal workflow.

These findings suggest that additively manufactured dies are not merely theoretical substitutes, but viable tooling for short-run cold embossing processes, especially where rapid fabrication, low tooling cost, or repeated iteration are important. They do not displace brass in every context, particularly where heated workflows or long-run durability are essential, but they do expand the practical tooling options available to commercial print manufacturers.

Design and Optimization of a Sustainable Water-Based Ink for Inkjet Printing of Fluorescent Functional Materials

Elsa Bihel^{1,2}, Aureore Denneulin¹, Damien Boyer², Anne Blayo¹

¹University of Grenoble Alpes, CNRS, Grenoble INP, LGP2, F38000 Grenoble, France

²University Clermont Auvergne, Clermont Auvergne INP, CNRS, Institut de Chimie de ClermontFerrand (ICCF), F-63000, Clermont-Ferrand, France.

elsa.bihel@grenoble-inp.fr; aureore.denneulin@grenoble-inp.fr; damien.boyer@sigma-clermont.fr; anne.blayo@grenoble-inp.fr

Abstract

Research in luminescent materials has received significant interest due to the numerous applications that have emerged, including anti-counterfeiting, display technologies and photovoltaics. A challenge in these applications lies in the deposition of luminescent films. There has been an interest in developing luminescent inks via printing processes, particularly inkjet. The growing emphasis on environmental sustainability is leading research to favour water-based inks. The objective of this work is to develop fluorescent functional materials for water-based inkjet inks.

The luminescent dyes and particles are carefully selected for stability and compatibility with water-based systems. In addition to the water, co-solvents and additives are incorporated to fine-tune surface tension and viscosity, optimizing inkjet ejectability and print quality. The inkjet inks are deposited onto various substrates to evaluate how printing parameters influence fluorescence performance.

Work results demonstrate promising fluorescence uniformity and intensity on different substrates with water-based inks balancing sustainability and functionality. The inks exhibited physicochemical properties compatible with inkjet printing and produced fluorescent thin films with significant emission intensity after printing. Optimizing concentration, thickness and surface interactions show potential for scalable, eco-friendly luminescent coatings with tailored optical properties for applications in displays, security, and sensing.

Rheological Behaviour and Printability of Water-Based Model Inks for Screen Printing

Abdullah Javed¹, Nadège Reverdy-Bruas¹, Matthieu Robert de Saint Vincent¹, Céline Martin¹

¹ Université Grenoble Alpes, CNRS, Grenoble INP, LGP2, F-38000 Grenoble, France Institute of Engineering Université Grenoble Alpes

abdullah.javed@grenoble-inp.fr; nadege.reverdy@pagora.grenoble-inp.fr; matthieu.robert@grenoble-inp.fr; celine.martin@grenoble-inp.fr

Abstract

The development of environmentally-friendly inks for printed electronics motivates the design of inks with limited amounts of additives, raising the question of the specific role of each ingredient in ink formulations. This work explores the individual and combined effects of binder and conductive filler on the rheology and printability of a simplified, water-based model ink adapted for screen- printing. We formulated 2-hydroxyethyl cellulose (HEC) with graphite particles inks in various concentrations and assessed their rheological behaviour and printability. The ink rheology, featuring Carreau-like behaviour and thixotropy, was mostly driven by the vehicle with corrective effect of the particles at high concentrations, under high and low shear rates. Screen printing on plain and electronic paper substrates showed that printability depends mostly on substrate type, with higher surface coverage on the former than on the latter

Paper-based PCB – Cellulosic fibres and functional ink separation towards recycling

Arnel Brzovic^{1,2}, Nathalie Marlin¹, Denis Curtil¹, Maria Lupsea², Lenka Svecova², Nadège Reverdy-Bruas¹

¹Univ. Grenoble Alpes, CNRS, Grenoble INP (Institute of Engineering Univ. Grenoble Alpes), LGP2, F-38000 Grenoble, France

²Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, Grenoble INP, LEPMI, 38000 Grenoble, France

arnel.brzovic@grenoble-inp.fr; nathalie.marlin@grenoble-inp.fr; denis.curtil@grenoble-inp.fr; maria.lupsea@grenoble-inp.fr; lenka.svecova@grenoble-inp.fr; nadege.reverdy-bruas@grenoble-inp.fr

Abstract

Millions of tonnes of electronic waste are generated annually in the European Union, creating significant environmental challenges. The E.U. project CircEl-Paper proposes a novel approach to electronic design by developing multilayer printed circuit boards (PCBs) based on circular economy principles. These PCBs are made primarily from paper, a material with strong recycling potential, and incorporate sustainable bio-based resources and environmentally friendly materials. This study investigates how conventional paper and board recycling processes can be adapted to recycle a simple paper-based electronic device developed in the project: an RFID antenna printed with silver-based ink. Three typical recycling operations—pulping, centrifugal cleaning, and flotation—were first tested separately at laboratory scale. Results showed that the paper-based PCB easily breaks down during standard pulping, causing the silver tracks to detach from the paper and fragment into particles between 10 and 100 µm in size. Due to silver high density, centrifugal cleaning efficiently concentrates Ag particles in one stream with 60% separation yield from the cellulosic fibers. Although silver is not naturally hydrophobic and therefore not ideal for flotation, its small and porous particles are nevertheless removed with about 70% efficiency due to entrainment in bubble trails. Finally, when the three processes were combined in a complete recycling line, fibers and silver were efficiently separated into two streams, achieving over 90% fiber recovery and more than 80% silver recovery. This demonstrates that conventional paper recycling processes can successfully treat simple paper-based electronic devices.

Electrochromic ink based on a cellulosic matrix for fully printed multilayer electrochromic devices

Lilou Boutarin^{1,2}, Julien Bras^{1,3}, Daniel Bellet^{2,3}, Aline Rougier⁴, Aurore Denneulin¹

¹University of Grenoble Alpes, CNRS, Grenoble INP, LGP2, F38000 Grenoble, France

²University of Grenoble Alpes, CNRS, Grenoble INP, LMGP, F38000 Grenoble, France

³Institut Universitaire de France (IUF), F75000, Paris, France

⁴University of Bordeaux, CNRS, Bordeaux INP, ICMCB, Pessac, France

lilou.boutarin@grenoble-inp.fr; julien.bras@grenoble-inp.fr; daniel.bellet@grenoble-inp.fr; aurore.denneulin@grenoble-inp.fr

Abstract

Printed electronics is a growing market, requiring high-performance inks with tailored functionalities, particularly for flexible devices. Electrochromic devices are especially promising, as they can be integrated into flexible displays, solar cells and smart building for sunlight regulation. The application potential of these multilayer devices is therefore considerable.

Printed electrochromic devices consist of multiple functional layers that must interact efficiently with each other to enable redox reactions responsible for color switching. Ensuring stable and homogeneous ink formulations is essential to warrant the functionality of electrochromic particles. In this context, the objective of our research is to develop innovative bio-based ink formulations, with a specific focus on the design of sustainable binders suitable for screen-printing.

The electrochromic ink developed in this work combines tungsten oxide (WO₃) particles as the functional material with a cellulose nanofibril-based matrix. Previous works have showed the interest of using cellulose nanofibrils for ink formulation. Besides its natural abundance and non-toxicity, cellulose nanofibrils owns an excellent dispersing capability, and a favorable rheological behavior for screen-printing applications.

The developed inks were coated onto polymer films PET coated with indium tin oxide (ITO). To assess electrochromic performance under the behavior, a specific methodology was developed to monitor color changes of the printed layer as a function of the applied electrical potential.

Stable and homogeneous electrochromic inks integrating a biobased binder were successfully formulated. Preliminary results show that a weak electrochemical response can be achieved with as little as 5 wt% electrochromic particle loading. These results are very promising, and further investigations are currently underway to optimize device performance.

Influence of Carbon Ink Type on the Sensitivity of Screen-Printed Humidity Sensors

Maëlle Reigner, Rafika Selmi, Jean-Charles Fustec, Maxime Harnois, France Le Bihan

Institut d'Electronique et des Technologies du Numérique (IETR), CNRS UMR 6164, 35000 Rennes, France.

Abstract

Flexible and low-cost humidity sensors are increasingly required for environmental, agricultural, and industrial monitoring. In this work, flexible resistive humidity sensors were fabricated by screen printing using four carbon-based conductive ink formulations: two water-based inks (carbon nanoparticles and graphene) and two solvent-based carbon nanoparticle formulations using different polymer binders (PEI and acrylic). The sensors were characterized under controlled humidity cycles ranging from 30 to 90 %RH.

The results reveal a strong influence of ink formulation on sensor sensitivity. Water-based inks exhibit significantly higher sensitivities than solvent-based inks, with a maximum sensitivity of approximately 0.6 %/%RH obtained for the graphene ink. The effect of the graphene layer thickness was also investigated, highlighting the influence of film structure on the hygrometric response. These results demonstrate the potential of water-based graphene inks for the fabrication of low-cost flexible humidity sensors with scalable printed electronics technologies.

Ribbing or Shaping Paper and Board by Printing: A Novel Functional Printing Approach to Lightweight Paper-based Packaging

Jérémy Viguié

University of Grenoble Alpes, CNRS, Grenoble INP, LGP2, F38000 Grenoble, France

Abstract

To address today's environmental and societal challenges, it is essential to drastically reduce the use of petroleum-based materials. Paper represents a promising biobased, recyclable and biodegradable alternative. However, the papermaking industry must continue to evolve by reducing its water, energy and wood consumption while improving the mechanical and moisture-resistance properties of paper and board. One promising strategy is to reduce the weight of paper-based materials while maintaining their mechanical performance. An innovative, bioinspired approach has been developed to significantly decrease the weight of paper and board packaging through a novel functional printing approach. This concept relies on increasing the bending stiffness of paper or board through the creation of ribbed, embossed or corrugated patterns inspired by natural structures such as leaves and nut or peanut shells. These structured materials are produced using versatile, low-cost processes based on printing biobased gel patterns onto paper or board. Results show that this "soft architecturing" approach can reduce packaging weight by up to 30% while maintaining equivalent mechanical performance, without requiring additional thermal or mechanical energy.

Advances in Recycling Strategies for Multilayer Food Packaging – Current Approaches to Address Non-Recyclable Packaging Systems

Volker Jansen

Print Media and Packaging Technologies, Hochschule der Medien, Nobelstraße 10, 70569 Stuttgart

Abstract

Multilayer plastic packaging accounts for approximately 13% of total plastic packaging and about 28% of flexible plastic packaging worldwide. It combines distinct polymer layers to achieve superior barrier performance, mechanical stability, and extended shelf life. However, the deliberate material heterogeneity that enables functional advantages simultaneously creates substantial end-of-life challenges. Multilayer structures are largely incompatible with conventional mechanical recycling systems and are therefore frequently directed to incineration or downcycling pathways, undermining circular economy objectives.

This study analyses current technological approaches to recycling multilayer food packaging and evaluates their environmental, technical, and economic limitations. A systematic literature review is combined with expert-informed scenario analysis to examine secondary (mechanical), thermochemical (pyrolysis-based), and solvent-based chemical recycling strategies. The analysis highlights structural constraints of mechanical recycling, including polymer immiscibility, contamination, and quality degradation. Thermochemical conversion enables feedstock recovery but is limited by high energy demand, contaminant variability, and the need for multi-stage upgrading processes. Solvent-based separation technologies such as the STRAP process demonstrate potential for high-purity polymer recovery; however, solvent regeneration, impurity accumulation, and scale-up complexity significantly affect environmental performance.

The findings reveal a structural gap between ambitious regulatory targets, particularly under the EU Packaging and Packaging Waste Regulation, and the technological maturity of existing recycling infrastructures. No single pathway currently provides a comprehensive solution. Instead, a hybrid recycling landscape integrating mechanical, thermochemical, and solvent-based approaches appears most realistic in the near term.

The study concludes that achieving circularity for multilayer food packaging requires systemic alignment across material design, advanced separation technologies, purification strategies, economic incentives, and regulatory frameworks.

Printing stiffeners on corrugated board boxes: a bio-inspired strategy to lighten packaging

Maxime Legay, Jérémie Viguié, Isabelle Desloges, Davide Beneventi

Université Grenoble Alpes, CNRS, Grenoble INP, LGP2, Grenoble, France

Abstract

Reducing the environmental impact of packaging requires both replacing plastics and optimizing the use of bio-based materials such as paper and cardboard. Although corrugated board is recyclable and biodegradable, its production remains resource-intensive, motivating strategies to reduce material usage without compromising mechanical performance. This study explores a bio-inspired approach based on printing rib-like stiffening patterns on corrugated board using fused deposition modelling (FDM) of poly(lactic acid) (PLA) as a proof of concept, with the objective of ultimately replacing it with an extruded cellulose-based paste. Box compression tests coupled with stereo digital image correlation (DIC) were used to analyze deformation mechanisms and map full-field strain distributions. Failure is governed by panel buckling followed by crease initiation, with strain concentrations mainly located in the corner regions. Reinforcement patterns were designed by exploiting these findings. Printed stiffeners delay crease formation and allow larger deformations before collapse, resulting in a compression strength increase of up to 50% for a mass increase below 30%. These findings highlight the potential of strain-driven, bio-inspired design to enhance the mechanical efficiency of corrugated board packaging.

Contextualizing the Emergence of Food Packaging: Processes – Materials – Periods

Athanasios Stathopoulos¹, Marios Tsigonias¹, Aristotle Tympas²

¹Department of Graphic Design and Visual Communication, University of West Attica, Egaleo, Greece

²Department of History and Philosophy of Science, National and Kapodistrian University of Athens, Athens, Greece

astathopoulos@uniwa.gr

Abstract

Food packaging history has often been presented through fragmented narratives that separately emphasize container design, material substitution, or regulatory developments. Such approaches rarely treat packaging as an integrated technical system shaping the organization of food production and circulation. This study reconceptualizes food packaging as food provisioning infrastructure, arguing that its historical evolution is best explained through processes of system integration, standardization, and industrial scaling rather than through intrinsic material superiority. It asks: How did packaging develop from discrete transport containers into synchronized industrial systems? Under what conditions did materials prevail? Do major transitions in packaging reflect systemic reconfigurations rather than simple material replacement? Methodologically, the research undertakes a historically grounded systems analysis based on comparative examination of key foundational scholarship (Twede (2002, 2005, 2012, 2016), Pearson (2016), Robertson (2019), Spiekermann (2011), and Hawkins (2012)), and selected primary marketing sources, including advertisements, trade press material, company catalogues, and packaging labels. Technical transformations—forming, sealing, dimensional precision, mechanization, and logistical alignment—are organized within the analytical framework Processes–Materials–Periods. The findings identify three structural transitions across contexts: regime compatibility in pre-industrial transport systems; industrial integration characterized by sequential machine linking, conveyor-based continuous flow, machinable sanitary design, and escalating throughput, reinforced by institutional standardization; and third, nested system expansion into retail infrastructures, regulatory harmonization, industrial consolidation, and global distribution networks. Structural shifts in packaging correspond to the integration of sequential operations into continuous production systems that enabled repeatability and large-scale output. Material changes mostly reflected infrastructural and institutional compatibility. As integration intensified, environmental externalities became structurally embedded. The study concludes that packaging operates as a synchronizing infrastructure coordinating food provisioning and shaping environmental performance through the configuration of production, distribution, and recovery systems rather than through material substitution alone. By foregrounding system dynamics over isolated artefacts, this research contributes a unified historical framework for packaging, printing, and process-engineering scholarship.

Sustainable printed and integrated electronics - Building the next generation of skills through academia–industry collaboration

Nadège Reverdy-Bruas^{1*}, Delphine Bechevet², Philippe Guaino³, Gaël Déprès⁴, Denis Curtil⁵, Jean-Marc Duchamp⁶

¹Univ. Grenoble Alpes, Grenoble INP*, Pagora, F-38000 Grenoble, France

²HES-SO, HEPIA, Geneva, Switzerland

³CRM Group, Belgium

⁴FEDRIGONI, Voiron, France

⁵Agefpi, 461 Rue de la Papeterie, CS 10065, Domaine Universitaire, Saint-Martin-d'Hères, France

⁶Univ. Grenoble Alpes, F-38000 Grenoble, France

nadege.reverdy-bruas@grenoble-inp.fr

Abstract

As the world becomes increasingly connected (IoT, AI, big data) and technological demand continues to grow, it is essential to banish the linear economic model that has developed since the industrial revolution. It is therefore necessary to seek sustainable solutions that are part of a circular economy.

Printed electronics can address the challenge of circularity firstly because it is an additive method, using only the necessary material to produce the devices. It also allows to design more sustainable substrates and functional inks using bio-sourced materials.

In this framework, several research projects have demonstrated that specific skills were required in order to manage projects dealing with functionalisation of objects (2D or 3D) with electronics. Therefore, dialogue workshops were organised with French as well as abroad companies and with Universities in France and abroad highlighting the lack of training at Master's level in Europe. In this context, a master's degree has been built at Université Grenoble Alpes, Grenoble INP-Pagora. The major e.PEPS, "Sustainable printed an integrated electronic" is a one-year program, part of the Master "Industrial Engineering" of Grenoble INP-Génie Industriel.

The Master has been launched in September 2025 and the first promotion will graduate in August 2026. Ten students coming from India, Tunisia and Pakistan attended the lectures and have been selected for internships in spin-off as well as in big companies and also in research laboratories.

The key point in training students coming from very different backgrounds – industrial engineering, material science, electrical engineering - was to provide them with the necessary skills required to manage and solve the challenges of printed electronic in a circular economy approach. The journey of this first promotion will be described as well as the fruitful cooperation with the partners of the master.

Hands-on Student Tutorial: Printing Technology and Applications in Printed Electronics - A “Printed Piano” Case Study

Thorsten Euler^{1,2}, **Pauline Rothmann-Brumm**^{1,2}, **Andreas Blaeser**^{2,3}

¹Technical University of Darmstadt, Department of Mechanical Engineering, Institute of Printing Science and Technology, Magdalenenstr. 2, 64289 Darmstadt, Germany

²Technical University of Darmstadt, Department of Mechanical Engineering, Institute for BioMedical Printing Technology, Magdalenenstr. 2, 64289 Darmstadt, Germany

³Technical University of Darmstadt, Centre for Synthetic Biology, Schnittspahnstr. 10, 64287 Darmstadt, Germany

euler@idd.tu-darmstadt.de; rothmann-brumm@idd.tu-darmstadt.de; blaeser@idd.tu-darmstadt.de

Abstract

The tutorial “Printing Technology and Applications in Printed Electronics” was developed at the Institute of Printing Science and Technology (IDD) at the Technical University of Darmstadt. Its purpose is to provide students (Master’s programs in Mechanical Engineering and Industrial Engineering) with in-depth technical knowledge regarding printing technology, the diverse range of printed products, and printed electronics.

In the introductory section of the tutorial, the theoretical principles of printed electronics are conveyed in a practical, hands-on manner using a specific project example: the “Printed Piano”. Students are provided with a pre-defined circuit design, along with a brief introduction to breadboards and standard circuit symbols. Their task is to identify how this electronic piano works and how the circuit can be used to generate different musical tones. Once they have worked in groups to understand the circuit’s operation, the students proceed to manually apply functional inks using various techniques.

This manual application process allows for the creation of thin, uniform layers featuring complex geometries. Depending on the specific structure applied (whether thin lines, thick lines, or meandering patterns) varying levels of electrical resistance can be achieved. The students are now tasked with using their painted or printed piano to play a simple musical piece, taking advantage of the varying resistances of the functional ink. This specific component of the tutorial serves to demonstrate to students how functional materials for printed electronics can be utilized.

To show the students the broad variety of printing technology, the tutorial does not only cover printed electronics but also graphical printing. During the tutorial, students are challenged to independently produce several items using the machinery available at the institute: a custom-designed notepad, a printed beverage bottle, a printed and foil-finished fabric tote bag, a printed illuminated bottle holder, and an electroluminescent panel featuring a flexible, foil-based design. In doing so, they utilize various conventional printing methods, including screen, flexographic, pad, and offset printing, as well as post-press finishing techniques (cutting, adhesive binding, embossing), and laser structuring. By the end of the tutorial, students are expected to apply the knowledge they have acquired to independently develop a novel demonstrator related to a specific topic within the field of printed electronics.

The tutorial “Printing Technology and Applications in Printed Electronics” offers a unique opportunity to explore the diversity of printed products and the applications of printing techniques within the field of electronics. Through the practical application of theory and the opportunity to develop and realize their own product concepts, students gain a comprehensive understanding of printing technology and printed electronics.

Emerging Technologies in Printed and Flexible Electronics (PrintElec - Unite!)

Olga Rac-Rumijowska^{1*}, Patrycja Suchorska-Woźniak¹, Nadège Reverdy-Bruas², Caterina Soldano³, Marco Sangermano⁴, Piergiorgio Rossi⁴

¹Wrocław University of Science and Technology (WUST),

²Univ. Grenoble Alpes, Grenoble INP*, Pagora, F-38000 Grenoble, France A (G-INP),

³Aalto University (AAO),

⁴Politecnico di Torino (PoliTO)

olga.rac-rumijowska@pwr.edu.pl

Abstract

In light of the rapid development of printed technologies and the growing importance of interdisciplinary engineering education, initiatives that combine theory with practice and bring together the academic community and industry are becoming particularly significant. This presentation will outline the objectives, goals and implementation plan for the international Blended Intensive Program (BIP) “Emerging Technologies in Printed and Flexible Electronics (PrintElec – Unite!)”, organised jointly by researchers from Wrocław University of Science and Technology, Grenoble INP - Pagora, Aalto University and Politecnico di Torino.

The proposed Blended Intensive Programme (BIP) responds to the growing demand for specialists in the field of printed and flexible electronics, which finds applications in, amongst other things, sensors, wearable systems and smart packaging. The teaching programme has been designed as a hybrid course, combining a theoretical component delivered online with an intensive practical module conducted on-site in laboratories. The first implementation of this BIP is expected in summer 2027, upon internal BIP approval. It will take place at Wrocław University of Science and Technology, and in subsequent years its location will rotate among partners institutions involved in the project. The theoretical component comprises lectures by experts in materials engineering, functional printing technology and the design of electronic circuits on flexible substrates. Participants will gain an understanding of the latest trends and challenges in the field of printed electronics, which will better prepare them for the practical tasks. The workshop component will see participating students, working in international and diverse background teams carrying out projects in the field of printed electronics. In first edition particular emphasis will be placed on screen-printing as one of the most accessible and scalable methods of manufacturing electronic structures. This method was chosen because it is easy to implement during a short time of training, and the Wrocław University of Science and Technology has a ready-made and complete screen-printing technological line adapted to teaching classes. Participants will go through the full project cycle – from concept, through stencil preparation and the printing process, to testing and analysis of the resulting circuits.

This presentation will also cover the organizational aspects of the project, including the model for international cooperation, methods of student engagement, and approaches to evaluate learning outcomes. The potential benefits of participating in the programme, for both students and partner institutions, will also be discussed.

The “PrintElec – Unite!” hybrid course, exemplifies a modern approach to technical education, integrating theoretical knowledge with practical skills and supporting the development of future-oriented competences. Its implementation helps to bridge the gap between the worlds of science, printing technology and education, thereby responding to the challenges of the modern labour market.

Keynote

Economic outlook and current trends of the EU printing industry

Laetitia Reynaud

INTERGRAF

Abstract

The presentation will provide an overview of recent economic developments in the European printing industry and highlight the key trends shaping the sector today. It will examine market developments across different segments and address key challenges, including the growing impact of regulatory requirements related to digitalisation and sustainability.

Functional printing: lightening paper through printing patterns

William Pierron¹, Tugdual Le Nir²

¹ Centre Technique du Papier, 59500 Douai, France

² Centre Technique du Papier, 38044 Grenoble cedex 9, France

william.pierron@webctp.com; tugdual.le-nir@webctp.com

Abstract

A first successful proof of concept has been achieved in a European project back in 2020 allowing to demonstrate that the printing of a specific pattern of starch on a paper substrate can bring high levels of rigidity. Indeed, the printing of such a pattern makes the paper to swell into a new 3D-shape product. This new shape is responsible of the increase in bending stiffness. The goal of the project behind increasing rigidity levels, is to be able to reduce the weight of packaging papers and boards while maintaining mechanical properties. New research has been carried out to study this phenomenon and to better understand it. A new paper was chosen to carry out the studies, more representative of an industrial substrate that could be used for packaging applications. New printings have been realized, replacing starch with micro fibrillated cellulose (MFC) allowing high levels of rigidity with low levels of printed materials. Multiple designs have also been investigated in order to characterize the influence of the pattern on the created 3D-shape. Both design and formulation used for the printings has shown high impact on the final shape. It was shown that the grid should cover the largest possible amount of the substrate while maintaining holes large enough between the lines in order to allow the paper to swell into a new 3D-shape. Moreover, it has been demonstrated that results of MFC deposition are similar to the one with starch while printing far less dry matter on the substrate, which allows better lightening of paper at the end.

Inkjet printing on moulded cellulose with bio-based inks

*Élise Jacachoury¹, William Pierron², **Anne Blayo¹***

¹ Univ. Grenoble Alpes, CNRS, Grenoble INP, LGP2, 38 000 Grenoble, France*

**Institute of Engineering Univ. Grenoble Alpes*

² Centre Technique du Papier, 59500 Douai, France

elise.jacachoury@lgp2.grenoble-inp.fr; william.pierron@webctp.com; anne.blayo@grenoble-inp.fr

Abstract

In recent years, moulded cellulose has attracted increased interest from the scientific and industrial community and is being used exponentially in many fields, with rapidly growing interest as a replacement for plastic in the packaging sector. It is, therefore, imperative to analyse the processes by which it would be possible to customise this material as a printing substrate, and the objective of this project is to demonstrate its feasibility using 100% biobased ink with inkjet printing. For the sake of consistency with regard to sustainability and environmental protection, the study focused on the formulation of water-based inks using bio-based soluble dyes. Several natural dyes appeared to be promising, and inks formulated produced interesting colours and sharp printing.

Protection of print on labels with various overprint varnishes

Prashant R. Kotkar¹, Kholoud S. Al Ajlouni² and Alexandra Pekarovicova²

¹RR Donnelley, Angola, IN

²Center for Coating and Printing Research, Chemical and Paper Engineering, College of Engineering and Applied Science, Western Michigan University, 4601 Campus Drive, A-217 Floyd Hall, Kalamazoo, MI

Abstract

Label stock was flexo printed, and the print was protected with overprint varnish (OPV). Three different OPV formulations were flexo-printed on the surface of flexo printed label design. Three assorted aniloxes with different resolutions and volumes were employed. A Taber abrasion tester was utilized to examine OPV durability. Taber adhesion testing resulted in the conclusion that among three different commercial overprint varnishes, OPV 2024 gave the best protection when using an anilox of 360 LPI resolution with volume 6.0 BCM, which means that this anilox deposited the thickest layer of overprint varnish. The OPV 2024 had the same components as OPV 2020, plus acylated polysiloxanes and pentaerythritol esters, which made this formulation the most powerful varnish for label design protection.

From Packaging to Learning: Print, Systems, and Technical Education

Athanasios Stathopoulos^{1*}, Marios Tsigonias¹, Aristotle Tympas²

¹*Department of Graphic Design and Visual Communication, University of West Attica, Egaleo, Greece*

²*Department of History and Philosophy of Science, National and Kapodistrian University of Athens, Athens, Greece*

mtsigonias@uniwa.gr, tympas@phs.uoa.gr; astathopoulos@uniwa.gr

Abstract

This paper proposes a reconfiguration of technology education through the lens of socio-material performativity and transformative innovation policy. Building on a critical analysis of food packaging as a performative infrastructure—shaping consumption practices, value construction, and environmental externalities—the study argues that current education models remain anchored in linear and technocratic paradigms of innovation. These paradigms correspond to the dominant “R&D” and “national systems of innovation” frames, which prioritize scientific output, commercialization, and system efficiency, while insufficiently addressing the socio-technical consequences of technological systems.

Drawing on the third frame of transformative change, this paper identifies a structural mismatch between contemporary societal challenges—such as sustainability, inequality, and resource-intensive production—and the epistemological foundations of technological education. Socio-material analysis conceptualizes food packaging as a performative “market device” that co-constitutes markets, institutions, and everyday practices, actively shaping how food is valued, governed, and consumed (Hawkins, 2012). Historically grounded in the rise of plastics and the institutionalization of packaging as an industrial and scientific field, packaging has evolved into a central organizing force in modern food systems, structuring norms of hygiene, freshness, convenience, and disposability while mediating between production, distribution, and consumption (Smil, 2023; Twede, 2016; Hawkins, 2018). Through processes such as branding, visual staging of freshness, and informational labeling, it performs value, guides consumer behavior, and embeds broader environmental and political consequences (Freidberg, 2009; Hisano, 2019; Frohlich, 2017).

Innovation policy literature reveals key educational imperatives. Future technologists must develop bridging competencies between technical expertise and social sciences, enabling them to engage with systemic challenges rather than isolated technical problems. Their education should foster reflexivity, equipping learners to question underlying assumptions of technological systems rather than optimizing within them. Curricula should support anticipatory capacities, allowing professionals to evaluate long-term environmental and social impacts of technological pathways (Schot and Steinmueller, 2018).

Within this framework, print and material culture—exemplified by packaging—are repositioned as pedagogical tools that mediate between technical design and social meaning. By integrating performativity analysis with innovation policy insights, the paper proposes an interdisciplinary educational model oriented toward sustainability transitions. It argues that, technological education must move beyond producing technical experts toward cultivating agents capable of engaging with the political, social, and material dimensions of system transformation.

Session 6B: Future orientations for Print-Media Education

Developing Competences for Sustainable Thinking through Linked Modules on Circular Economy and Process Design in the Printing and Packaging Industry

M. Eng. Dominik Kantek, Prof. Dr. rer. nat. Lutz Engisch, Dr. Simon Hamblyn, M. Eng Kilian Menzel

*dominik.kantek@htwk-leipzig.de; lutz.engisch@htwk-leipzig.de; simon.hamblyn@htwk-leipzig.de;
kilian.menzel@htwk-leipzig.de;*

Abstract

The ongoing shift of the printing and packaging industry towards greater sustainability poses a major challenge not only for businesses but also educational institutions teaching and training future specialists. Educational programmes must not only teach technical and engineering expertise but also convey environmental awareness and regulatory understanding. Graduates in printing and packaging technology must be able to understand and evaluate environmental performances and possess engineering qualifications, whilst also addressing legal frameworks like the European Packaging and Packaging Waste Regulation (PPWR). To meet these educational challenges, a two-semester teaching concept has been introduced. This concept allows students to engage with a practical project expanding over two consecutive semesters, while systematically embedding Life Cycle Assessment (LCA) and design-optimisation thinking into the curriculum.

This learning approach encompasses two lecture modules: "Circular Economy" and "Sustainable Material, Product and Process Development", the latter of which is further subdivided into "Product Development" and "Process Development" and spans two semesters. Together, these modules form a coherent learning pathway, connecting theoretical foundations of circularity with active engagement in sustainable product development. Within this framework, students are confronted with practical problem-solving tasks involving analysing, assessing and redesigning real packaging solutions in alignment with core concepts of the PPWR. This educational approach utilises a standardised method for Product Carbon Footprint (PCF) assessment, called "Sustainability in Printing" (SiP). By providing a consistent framework for conducting LCAs, this methodological standard enables students to quantify and compare various environmental impacts across design options. It follows an iterative and relative approach comprising the four phases of LCA. SiP specifies the use of the Cradle-to-Gate boundary in conjunction with the specialised LCA software openLCA and the ecoinvent database, enabling comparable assessments. SiP also supports users e. g. by providing interactive data collection forms.

In the first semester, students will learn core concepts of circular economy and circularity. This includes an introduction to LCA and SiP. Simultaneously, students are divided into teams and select packaging solutions, evaluating their performance in terms of recyclability and material efficiency according to PPWR. In the following semester, the teams develop corresponding production workflows for before and after their improvements, reflecting realistic printing and converting 1 processes, while keeping technical feasibility in mind. Additionally, SiP will be used as a tool to evaluate various environmental impacts, such as the global warming potential. At the end of the second semester, the students will present their work.

This integrative format is designed to encourage students to combine regulatory analysis, technical design and quantitative sustainability assessment within a continuous project framework. The approach will be implemented in the upcoming course cycle, where students will explore the interrelations between design decisions, environmental performance and regulatory compliance. By linking two complementary modules over an extended timeframe, this concept aims to support long-term learning and enable iterative project development. The paper will present the didactic structure, methodological integration, and intended learning outcomes, outlining how this educational approach is expected to prepare graduates for the industry's ongoing transition toward climate-conscious and regulation-compliant packaging production.

The Transformation of the Graphic Arts Sector: Emerging Opportunities Through Artificial Intelligence and Machine Learning

Chris Trochoutsos^{1,2,3}, Gerasimos Vonitsanos^{1,2}, Marios Tsigonias^{1,2}

¹University of West Attica, Hellenic Graphic-Media Research Lab – GRAPHMEDLAB, Greece

²Hellenic Open University, School of Applied Arts and Sustainable Design, Greece

³Pressious Arvanitidis, printing company, Greece

Abstract

The Graphic Arts sector is not a profession many people would associate with machine learning or artificial intelligence. But this is totally wrong. After the Industry 4.0 revolution, big data is being generated through Management Information Systems in cooperation with IoT.

In general, Artificial Intelligence and Machine Learning are being increasingly used in the graphic arts field to improve processes and create new opportunities. From the prepress phase to the postpress procedures, there are numerous cases where AI and ML can be used to create, automate, predict, and make better decisions.

As far as graphic design is concerned, AI tools can generate text, photographs, and even videos, and, of course, there are many tools that use AI algorithms for image and video manipulation. Furthermore, ML algorithms can generate new design elements or suggest modifications to existing designs, reducing the need for manual design work. Other examples for the prepress department include colorizing black-and-white images, 3D modeling, and more realistic and interactive virtual and augmented reality experiences.

In the production process, AI and ML can automate many tasks, saving the company time and money. Automated workflows, predictive tools, and smart decision trees are among the ways to optimize production, increase profitability, and improve market competitiveness. Digitalization of physical processes, aka creating digital twins and applying AI algorithms to them, is an excellent way for a simulated environment to test and validate modifications.

The paper intends to present some of the tools that AI and ML can offer to the graphic design and printing industry.

Digital printing applications on scenography – The “HAMAM” Theatrical performance case study

Dr. Charalampos Sepentzis^{1,2,3}, Anastasios Politis^{2,3}

¹*University of West Attica, Egaleo, Greece*

²*HELGRAMED - Hellenic Union of Graphic Arts & Media Technology Engineers, Athens, Greece*

³*GRAPHMEDLAB - Hellenic Print-Media Research Lab, University of West Attica, Egaleo, Greece*

Abstract

Previous research conducted, revealed that the application of graphic arts technologies are quite suitable for supporting a theatrical performance with scenography, costume design and visual communication.

In this paper, a case study for the application of digital printing at a theatrical performance is presented, exploiting the potential of digital printing applications for a theatrical performance.

Through the case study, the range of applications and the effectiveness of digital printing technologies, become apparent, as they can be applied in any format, number and dimension on a huge variety of substrates, while they provide a substantial time and cost reduction, for the construction of a setup.

A profound requirement for the application of digital printing and finishing technologies in the setup for a theatrical performance, is the requirement of deep knowledge of the range of digital printing technologies and finishing applications in relation with the materials/substrates to be applied.

Non-linear narratives on printed media

Iro Laskari

Hellenic Open University

Abstract

Can traditional printed media support non-linear narratives? Can print become interactive? Through the presentation of a pedagogical workshop on interactive storytelling, this paper proposes that interactivity is not restricted to digital media and that printed physical artifacts can support multiple readings of a structured story. While the overall narrative structure remains stable, its individual parts may vary. If a story is organized into distinct narrative units, following for example the stages of the Freytag Pyramid, each unit can generate multiple alternative versions. Different combinations and sequences of these narrative parts produce different readings, which the reader is invited to interpret. From a semiotic perspective, the proposed narrative artifacts can be understood through the relationship between syntagmatic and paradigmatic structures. The succession of paradigmatic variations along a syntagmatic axis generates multiple narrative paths, thus meanings. As a result, the narrative structure shifts from linear progression to networked configurations such as branching trees, stars, hypertextual systems composed of nodes and links. In this case, the challenge lies in embodying these structures through printed media.

Which printed artifacts can support non-linear readings? Since the 1960s, theories concerning the openness of the text and the “death of the author” (Barthes) have questioned the singularity of meaning. Which physical artifacts embody these theories? Which printed systems are capable of producing alternative readings from a stable structural framework? This research revisits playful and intuitive artifacts that already contained forms of interaction before the digital era. During our pre-digital childhoods, many of us encountered similar “toys” and analog mechanisms capable of generating combinatory experiences. How can such structures be rediscovered and adapted for contemporary storytelling practices? Through field research and practice-based experimentation, unexpected examples of narrative mechanisms emerged, which will be presented from new perspectives. In a digitized world where software frequently simulates physical metaphors such as folders, desktops, or bins, could the logic also be reversed? Could contemporary digital narrative structures enrich printed media and transform physical artifacts into interactive narrative systems?

Analog Resistance: Why Tactile Design Practices Still Matter in the Age of AI-Generated Graphics

Dr. Charles T. Weiss

Clemson University, Clemson, SC 29634

ctweiss@clemson.edu

Abstract

As graphic communication education becomes increasingly dominated by digital technologies and the advancement of AI technologies, educators face growing concerns about the diminishing role of analog design practices in the creative process. While software-based workflows emphasize efficiency, precision, and rapid production, they can also encourage premature design fixation and limit exploratory thinking. This paper examines the role of analog design processes in fostering design thinking within the graphic communication classroom and argues that tactile, hands-on methodologies remain essential for developing creative problem-solving skills, reflective practice, and human-centered innovation.

Drawing from design thinking theory, educational pedagogy, and creativity research, the study explores how analog methods—including sketching, hand lettering, printmaking, paper prototyping and packaging, and physical brainstorming exercises—support the core principles of empathy, ideation, experimentation, and iteration. The paper situates these practices within established frameworks by scholars such as Tim Brown, Donald Schön, and Nigel Cross, emphasizing the importance of reflective and experiential learning in design education. In contrast to purely digital workflows, analog processes encourage slower, more deliberate engagement with visual communication problems, enabling students to externalize thought, embrace ambiguity, and generate more diverse conceptual outcomes.

The paper further investigates how hybrid pedagogical models that integrate analog and digital methodologies can create more adaptive and innovative learning environments. Through classroom examples, studio-based exercises, and analysis of contemporary design education practices, the research demonstrates that analog activities not only enhance technical and conceptual understanding but also strengthen collaboration, critique participation, and cognitive engagement. Additionally, the study addresses contemporary challenges posed by artificial intelligence, template-driven aesthetics, and increasing reliance on automated creative tools, arguing that analog practices provide a critical counterbalance that preserves originality and individual design voice.

Ultimately, this research proposes that the future of graphic communication education should not position analog and digital methods in opposition, but rather as complementary components of a holistic design thinking framework. By reintegrating tactile and process-oriented experiences into the classroom, educators can cultivate more reflective, experimental, and innovative designers capable of navigating the evolving demands of contemporary visual communication.

Improving bio-based black pigments properties for coldset ink formulation

Jérémy Manificier¹, Anne Blayo¹, Agnès Boyer¹

¹ Univ. Grenoble Alpes, CNRS, Grenoble INP*, LGP2, 38 000 Grenoble, France

*Institute of Engineering Univ. Grenoble Alpes

jeremy.manificier@grenoble-inp.fr; anne.blayo@grenoble-inp.fr; agnes.boyer@grenoble-inp.fr

Abstract

To meet the environmental challenges of our century, new legislation is emerging to constrain industry to use inks formulated with bio-based materials. In the case of coldset printing, ink vehicles containing bio-based solvents are now common but very few studies have been carried out on the replacement of the pigmentary part with bio-based pigments. The aim of this study is to formulate black coldset inks containing bio-based pigments. The objective is to obtain sufficient optical properties for printed text to be readable. A black pigment obtained from the pyrolysis of softwood is used to formulate black inks. The pigment is ground and pyrolyzed to improve colorimetric properties of the resulting printed ink. Reducing the pigment size is found to be the main lever to improve optical density. Increasing the carbon content via pyrolysis allows to slightly modify the hue, leading to a deeper perceived black. Cumulating those operations allows to produce bio-based black inks with promising properties, although performances are not on par with industrial inks yet.

Quantifying dot gain mechanisms in flexographic highlight tones

Sofia Thorman, Cecilia Rydefalk

RISE Research Institutes of Sweden Department of Sustainable Materials & Packaging, Box 5604, SE-114 86 Stockholm, Sweden

sofia.thorman@ri.se; cecilia.rydefalk@ri.se

Abstract

Reproducing small dots is essential for smooth highlight tones in flexographic printing, but both mechanical and optical dot gain influence how dark these tones appear. Most earlier work focuses on offset printing and does not separate the contributions in flexography, where deformation of the raster dot on the print form and substrate compressibility play a key role. In this study we use high resolution scanning and histogram-based dot area estimation together with standard and modified Murray Davies calculations to account for internal dot reflectance and separate physical and optical dot gain. The method is applied to a full scale printed 4% tone on three coated liquid packaging paperboards differing in baseboard and top layer structure. The results show that all three mechanisms contribute to the apparent tone value in highlight tones. Differences between the paperboards were mainly reflected in the physical gain for the baseboards and in the optical effects for the top layers. The method provides a practical tool for identifying the dominant mechanism for a given substrate.

Prediction of gravure printed patterns using fluid splitting regime maps

Pauline Rothmann-Brumm¹, Thorsten Euler¹, Andreas Blaeser¹

¹Technical University of Darmstadt, Department of Mechanical Engineering, Institute for BioMedical Printing Science, Magdalenenstr. 2, 64289 Darmstadt, Germany

rothmann-brumm@idd.tu-darmstadt.de

Abstract

Gravure printing is a well-established, high-quality printing technology that often relies on the experience of the machine operator. A deeper understanding of the underlying fluid dynamics is crucial, particularly for emerging applications like biomedical printing and printed electronics. Using the publicly available HYPA-p image dataset, which comprises extensive experimental data from two gravure printing campaigns, we derive several regime maps of fluid splitting in gravure printing. These maps, a common tool in fluid mechanics but novel to gravure printing, correlate tonal value and printing velocity with the observed fluid splitting regime (point splitting, lamella splitting or transition regime). Our results demonstrate the influence of raster frequency, ink viscosity, machine type, ink type, substrate, and doctor blade angle on the resulting patterns. These regime maps provide a predictive tool for optimizing printing trials, conserving expert knowledge, and exploring unconventional process parameters for gravure printing. Future work will focus on leveraging the HYPA-p dataset even more by generating and analyzing all 152 possible regime maps.

Inkjet technology with water-based inks chemistry is ready to meet new challenges from August 2026

Enn Kerner, EUR ING

Abstract

Today and tomorrow, industries are following the industrial developments of inkjet printing, which has already rapidly expanded into new areas of non-contact digital printing technology. In the recent past, office printing of text and image documents has been declining as digital documents (PDF formats) have become widely used. In contrast, applications such as large-scale on-demand packaging printing and ultra-small-scale functional printing of microscopic volumes of precious or rare materials, formulated for precisely printed, digitally defined pattern arrays are rapidly increasing. These applications include printed diagnostics, flexible electronics, anti-counterfeiting technologies, and others.

The new Packaging and Packaging Waste Regulation (PPWR) is an EU regulation that will become effective on 12 August 2026. It introduces mandatory requirements for sustainability, recyclability, labelling, and waste reduction for all industrially printed packaging placed on the EU market.

«The AI Testament»: Anthropic's Claude AI, Figma, Printbox, DynamicsPrint and GelatoConnect within the contemporary Graphic Arts, Printing and Packaging Industry

Anastasios Politis^{1,2,3,4,5}, Alexandra Vergopoulou³

¹HELGRAMED - The Hellenic Union of Graphic Arts & Media Technology Engineers, Athens, Greece

²GRAPHMEDLAB - The Hellenic Graphic-Media Research Lab, University of West Attica, Greece

³Hellenic Open University, School of Applied Arts and Sustainable Design, Patras, Greece

⁴PackPrint Science - Hellenic Center for Research, Development & Education of Packaging, Printing and Graphic Communication, Schimatari, Greece

⁵University of West Attica, Greece

politismedia@gmail.com

Abstract

The notion of an “AI Testament” is intrinsically associated with the utilisation of Artificial Intelligence (AI) for the conservation of human heritage, principles, and bequests that extend far beyond an individual's mortal existence, through the establishment of an interactive digital persona, thereby ensuring the perpetuity of cultural heritage and accumulated knowledge and wisdom. Indeed, an “AI testament” in the printing sector denotes the codified transition of veteran printers' expertise from traditional human operators to AI expertise systems (Expert Systems), in order to prevent the critical knowledge and expertise of the workforce from diminishing as senior professionals retire, predominately by utilizing Machine Learning (ML) and AI within workflows, press settings, and habitual troubleshooting procedures. Concurrently, contemporary printing businesses are leveraging AI to establish a “testament” comprising an inventory of tangible human knowledge and expertise. Moreover, by embracing innovative and transformative concepts (e.g. Industry 4.0, Industry 5.0, digitalization, digital transformation, sustainability, circular economy, lean production, and continuous improvement), it is possible to engender a sophisticated and manifold environment, which places significant strain on human capital within the relevant sector/fields. Furthermore, novel concepts and integration tools emerged during 2026 (e.g. Anthropic's Claude AI, Figma, Printbox, DynamicsPrint, and GelatoConnect), as a salient embodiment of a novel data-driven strategy that was integrated into daily printing practices. In essence, the utilization of Claude AI, Figma, Printbox, DynamicsPrint, and GelatoConnect signifies a paradigm shift towards automation, cloud integration, and AI integration, while modern design platforms (e.g. Figma, or Claude AI) have the capacity to interface with print workflow management systems (e.g. Printbox), Enterprise Resource Planning systems - ERP (e.g. DynamicsPrint), and end-to-end management systems (e.g. GelatoConnect). Essentially, the aforementioned factors are intrinsically associated with the Enterprise AI (e-AI) model, within the Enterprise Knowledge (EK) framework, which highlights an organization's transition from rudimentary data summarization to autonomous decision-making, while it encompasses Descriptive AI, Diagnostic AI, Predictive AI, Prescriptive AI, Expert AI, and Agentic AI. Consequently, the advent of AI within the contemporary Graphic Arts, Printing and Packaging Industry has precipitated a paradigm shift, serving as the key impetus for the emergence of Industry 4.0 (e.g. automation and data interoperability) and, concomitantly, for the transition to Industry 5.0 (e.g. human centricity and human-machine collaboration). However, a question of comparable significance emerges: A salient question pertains to the fate of the knowledge these individuals possess upon their demise. The challenge lies not only in the adoption of AI itself, but also in the integration of this technology into existing production systems and processes. This initiative is designed to safeguard the accumulated knowledge and expertise developed over the course of decades, ensuring that it does not diminish or become lost in the process of transformation; especially due to the fact the organizations thriving in this landscape will not merely be those that utilize AI proficiently. Indeed, the preeminence of AI is projected to persist, and even if businesses are undergoing transformations, there is an overarching imperative for continuous adaptation or risk being left behind. This necessity arises from the fact that the rise of AI is predicated on human productivity, as technology in the workplace undergoes a paradigm shift from Industry 4.0 to Industry 5.0.

Study Of The Influence Of Material Properties On Digital Electrophotographic Print Product Quality And Usage Characteristics

Daiva Sajek, Virginijus Valčiukas, Gitana Ginevičienė, Vidas Vainoras

Kauno kolegija HEI, Lithuania

Abstract

Currently, a wide range of printed products in graphic and packaging industry are produced on various materials, such as paper, plastic, films, cardboard, foils, etc. Despite the variety of materials and their different properties, high quality requirements are imposed on all printed products. Moreover, some of them have very fine details, that form special distinctive marks, various security signs, micro-lines or micro-text, barcodes, grids, etc. Such printed images are particularly sensitive to the properties of materials and their surface micro-irregularities. The accuracy of the reproduction of these images is important in order to obtain specific micro-images of precise dimensions on printed products. Also, accurate reproduction of screen micro-dots determines the quality of colour reproduction and the colour accuracy of image halftones. It is also very important to consider mechanical and environmental impact during the lifetime of the printed products, i.e. abrasion resistance, colour fastness during the aging, etc. Factors of environmental impact can affect the colour characteristics, brightness, as well as thin micro-lines, screen dots, definiteness and geometrical dimensions.

Although such products are printed using different techniques, currently digital printing technologies are increasingly used. Since one of the most commonly used techniques in digital printing is Electrophotography (EF), therefore, this study analysed print samples printed using two different dry-toner EF printers.

The research was initially focused on the evaluation of the quality of colour reproduction by spectrophotometry and the evaluation of abrasion resistance by ink rub testing. Samples with halftone fields and linear micro-images created for this purpose were printed on different types of substrate. Before printing, the characteristics of the substrate surface smoothness were determined. The halftones of printed samples were measured with a spectrophotometer X-rite Exact2 to determine ΔE , and vertical and horizontal micro-lines width of 0,01 mm were measured using the microscope Dino Lite AM4013MT. Then rubbing experiments were performed on Hanatek RT4 abrasion tester, and measurements of ΔE and micro-lines width after the rubbing were performed. Additionally, the influence of the accelerated ageing to the printed products colour resistance was monitored by using light exposure test apparatus Solarbox 522/1500 and exposing samples to short intervals of light for simulation effect using a 1500 W Xenon high pressure lamp. Then ΔE of the samples was repeatedly measured.

The results of the study showed a clear correlation between the surface smoothness of the printed material and colour tone accuracy, as well as geometric accuracy of micro-image detail reproduction. The experimental results also showed the influence of the simulated product's usage time on color fading.

Generative AI in Premedia Workflows: A Comparative Analysis of AI-Generated Images Against Print-Production Standards

Evgenia Pagani¹, **Andriani Goutou**¹, Marios Tsigonias^{1,2}

¹University of West Attika, Department of Graphic Design and Visual Communication, Hellenic Graphic-Media Research Lab, University of West Attica – GRAPHMEDLAB,

²Hellenic Open University, School of Applied Arts and Sustainable Design, Graphic Arts and Multimedia Master's Programme

epagani@uniwa.gr

Abstract

The rapid development of Generative Artificial Intelligence (GenAI) technology has introduced a range of image-generation AI engines into the Graphic-Media Communication industry. These GenAI models differ significantly in their core architectures, technical specifications, and image output formats. Most widely adopted commercial and open-source image-generation models are primarily optimised for on-screen display and therefore tend to generate relatively low-to medium-resolution raster images, typically in the range of 1024 px to 2048 px in the sRGB colour space, but recent developments have also enabled the image upscaling to 4K resolution and the production of vector graphics.

This study provides a comparative and experimental analysis of the selected GenAI models –Midjourney, DALL·E 3, Stable Diffusion, and Adobe Firefly– from a professional premedia perspective. The primary objective of the study is to evaluate their inherent capabilities with respect to established print production standards. The study systematically assesses AI-generated images with regard to their native pixel resolution, aspect-ratio constraints, and colour-space limitations to examine their suitability within professional premedia workflows.

The research methodology is based on an experimental framework in which a systematically designed set of text prompts is processed across all selected GenAI models. The generated image data set is then processed through a professional premedia workflow to evaluate its compliance with print industry standards. The evaluation criteria are quantitatively defined using the effective Pixels Per Inch (PPI) adequacy for the standard layout dimensions and the colorimetric accuracy evaluated through ΔE variations during RGB-to-CMYK profile to ensure precise image reproduction on the press.

Preliminary findings indicate that although current GenAI systems can generate visually compelling images, significant post-processing interventions remain necessary to satisfy professional print-production requirements, particularly regarding resolution adequacy, colour fidelity, and raster consistency. The analysis also reveals distinct technical profiles for each engine that quantifies the prepress viability of each GenAI model. In conclusion, the study proposes a technical evaluation framework designed to support publishers and premedia professionals in the selection, optimisation, and adoption of the most appropriate GenAI model for specific production scenarios, thereby ensuring that AI-driven creativity does not compromise print quality.

Designing Multimodal Print Products: Visual Communication in Tabletop Role-Playing Games

Konstantinos Athanasiou, Iro Laskari

Abstract

This paper examines tabletop role-playing games (RPGs) as multimodal print products and investigates their potential as pedagogical tools within graphic communication education, particularly in relation to the printing and production sectors. RPG rulebooks are hybrid and complex editorial artifacts in which typography, layout, illustration, color, and materiality operate as interconnected systems of communication. As such, they offer a compelling framework for connecting design theory with hands-on training in print-based practices.

Drawing on social semiotics and multimodal analysis, the study approaches visual communication as a meaning-making process shaped by design decisions across multiple layers. Elements such as typographic hierarchy, page composition, visual rhythm, and image-text relationships are examined as tools that structure information, guide navigation, and shape user experience. At the same time, RPGs are approached as hybrid print products, combining rulebooks with elements such as dice, maps, game master screens, cards, and collectible artifacts. These form integrated design systems rather than isolated printed objects. Within this expanded framework, visual communication operates across multiple formats and scales, requiring the coordination of graphic, material, and production decisions into a coherent whole. An RPG product is understood not merely as a carrier of content, but as a designed environment that actively mediates narrative engagement and reader immersion.

The paper provides a historical overview of graphic design in RPG publications, tracing their evolution from early rulebooks of the 1970s—characterized by dense layouts, limited color use, and utilitarian printing constraints—to contemporary publications that demonstrate sophisticated art direction, diverse visual languages, and advanced production techniques. This evolution reflects broader developments in graphic design and printing technologies, as well as shifts in audience expectations and market positioning.

Particular emphasis is placed on the material dimension of RPGs and its relevance to design education. Paper quality, printing methods, binding techniques, ink application, and finishing processes are examined as integral components of visual communication rather than secondary considerations. In contemporary RPG publishing, material choices often function as expressive tools, reinforcing thematic identity and enhancing user experience. From highly tactile collector editions to experimental, independent publications that challenge conventional layout and print norms, current trends in the RPG industry highlight the growing importance of materiality as part of the design process.

This perspective supports a broader educational approach to graphic communication, where design is understood as the synthesis of concept, visual language, and physical realization within contemporary print practices.

Evaluating the Effectiveness of Publicly Available AI Tools for Automated Image Background Replacement

Ivana Tomić, Ana Buntić, Jelena Vladušić, Sandra Dedijer

University of Novi Sad, Faculty of Technical Sciences, Department of Graphic Engineering and Design

Abstract

Artificial intelligence has significantly advanced the field of image editing, particularly in the area of background replacement. Leveraging deep learning models, AI-powered tools can now accurately detect and isolate foreground elements, enabling seamless background substitution. Most of the tools providing this option encompass generative AI, where the new background is created based on user inputs. A growing number of publicly available AI applications offer this functionality, making it accessible to users with little or no experience in image editing. This paper evaluates the visual quality of such AI-generated background replacements, focusing on the realism and coherence of the final output. As input, we used three photographs differing in the complexity of foreground-background separation. In the first image, the main object is clearly distinguishable from the background, facilitating easier selection, while in the remaining photographs, the separation of the main subject was more complex due to background similarity or the number of details. We tested numerous publicly available AI tools and narrowed our focus to three that enabled fast and user-friendly background replacement capabilities. Although the replacement process was rapid and the generated backgrounds matched the given descriptions, visual artifacts were observed in nearly all output images. These included residual pixels, localized color shifts, and poorly rendered shadows—particularly in images where the subject was clearly distinguishable from the background. In cases where the background shared similar texture and tonal characteristics with the main subject, the AI tools often introduced details not present in the original image. A further limitation of the free versions of these tools was that processed images could only be downloaded at 72 pixels per inch (PPI), even when the original images had higher native resolutions, making them unsuitable for printing. On the positive side, most tools included basic manual editing options, allowing users to refine results to some extent—an advantage particularly relevant for professional use. Overall, we conclude that publicly available AI tools for background replacement offer practical and accessible solutions for both amateur and professional users. While amateurs benefit from fast and simple image editing for digital publication, professionals can make use of generative AI to construct desired scenes without the need to search for suitable photographs.

From Compliance to Comprehension: Making Image Descriptions Useful in Online Retail

*Sheilae Siagian¹, Dr. Reem El Asaleh¹, **Lee Eldridge²**, Dr. Deborah Fels³*

¹School of Graphic Communications Management, Toronto Metropolitan University, 350 Victoria St., Toronto, Ontario, M5B 2K3 Canada

²Media & Design Innovation, Toronto Metropolitan University, 350 Victoria St., Toronto, Ontario, M5B 2K3 Canada

³Information Technology Management, Toronto Metropolitan University, 350 Victoria St., Toronto, Ontario, M5B 2K3 Canada

sheilae.siagian@torontomu.ca; reem.elasaleh@torontomu.ca; lee.eldridge@torontomu.ca; dfels@torontomu.ca

Abstract

The paper examines how alternative text (“alt-text”) shapes the accessibility and usability of e-commerce websites. Because online shopping is now a primary mode of commerce, accessibility is a practical requirement of inclusive design. Prior research has documented that effective alt-text is often missing or underdeveloped on e-commerce platforms. As a result, persons with visual impairment(s) may be unable to fully access product information and details, contributing towards dissatisfaction and reduced task success. This paper investigates the effectiveness of alt-text in e-commerce and asks how current standards and guidance support the generation of effective alt-text. The primary finding is the absence of a detailed, actionable standard for writing high-quality alt-text in common e-commerce contexts. Existing standards emphasize the importance of text alternatives but provide limited practical direction that publishers and content producers can apply when writing appropriate, user-friendly alt-text. In response, the paper examines how Artificial Intelligence (AI) tools, used in conjunction with human review and validation, may improve the speed, consistency, and accuracy of alt-text in image-rich websites and platforms. Overall, integrating AI-assisted alt-text workflows within e-commerce platforms has the potential to improve usability for screen reader users, streamline content workflows, and support a more inclusive digital shopping environment, with potential secondary benefits for search visibility.

AI-Driven Optimisation of Printing Production Using Neural Networks within a FAIR Data Framework

Chris Trochoutsos^{1,2,3}, Gerasimos Vonitsanos^{1,2}, Marios Tsigonias^{1,2}

¹University of West Attica, Hellenic Graphic-Media Research Lab – GRAPHMEDLAB, Greece

²Hellenic Open University, School of Applied Arts and Sustainable Design, Greece

³Pressious Arvanitidis, printing company, Greece

chtrox@presssious.com; gvonitsanos@uniwa.gr; mtsigonias@uniwa.gr

Abstract

This paper presents a neural network-based framework for predicting ink consumption in offset printing environments, leveraging structured FAIR data pipelines within the Cyclops framework. The proposed approach integrates heterogeneous production data, including machine parameters, environmental conditions, and material characteristics, into a unified data lifecycle to support AI-driven modelling. Both feedforward and recurrent neural network architectures are employed to capture static relationships and temporal dependencies within the printing process. The models are trained on multivariate industrial data to predict key sustainability indicators, especially ink consumption, and are evaluated using standard regression metrics. Results indicate improved prediction performance, particularly when temporal dynamics are considered, while the Cyclops-based data lifecycle supports structured, traceable, and interoperable data management for more efficient and sustainable printing production.

Accessible Publications: Regulatory Requirements and Problems of Digital Content Distribution for Persons With Disabilities

Virginijus Valčiukas, Daiva Sajek

Kauno kolegija HEI, Lithuania

Abstract

Relevance and aim of the research. On June 28, 2025, the European Accessibility Act (EAA) European regulations came into force, making the production of accessible eBooks mandatory for specific categories of publishers and digital service providers. The primary objective of this directive is to eliminate digital barriers and ensure that digital content is equally accessible to persons with various disabilities. However, accessibility encompasses a wide range of functional limitations. Even digital content that conforms to the highest technical standards often fails to meet the needs of individuals with severe, specific, or combined impairments, particularly in cognitive, language, and learning areas. Although a year has already passed since the directive entered into force, the transition to fully accessible digital publishing is proceeding very slowly. Publishers and distributors face technical, financial, and organizational challenges, causing the overall process of digital content adaptation to stall. Consequently, there is a critical need to evaluate the current state of implementation and identify the systemic bottlenecks in the digital content distribution chain. This study aims to review the main reasons why the accessibility process is stalling and to analyze the current distribution of certified accessible publications. The research compares available digital assets by publication genres, including fiction, non-fiction, informational publications, youth literature, and children's literature. Additionally, the study examines and compares the specific digital formats in which these certified publications are hosted in virtual repositories.

Methodology. The empirical research is based on a case study approach focusing on the ELVIS virtual library. This library is the primary Lithuanian digital platform offering accessible materials for individuals who cannot read standard printed text. The analysis relies on publicly available data provided by the ELVIS infrastructure. A qualitative content analysis was employed to classify the library's resources into distinct analytical categories based on genre specifications and technical formats. Furthermore, the identified resources were grouped into two broad functional categories: educational content and leisure content.

Findings. The findings reveal significant disparities in the availability of accessible digital literature. Accessible content is most widely developed and available for leisure purposes, dominating the fields of fiction and popular magazines. Conversely, digital resources directly related to formal learning, such as academic materials, scientific literature, and textbooks, are critically underrepresented. Materials intended for professional development and specialized training appear in an intermediate position, showing slow but steady growth.

Significance. The study highlights a clear mismatch between market supply and the educational needs of users with disabilities. The results indicate that while entertainment-oriented content transitions rapidly, the slow adaptation of educational and scientific texts severely limits access to lifelong learning and professional integration. These insights are valuable for policy makers, publishers, and academic institutions striving to comply with European accessibility requirements.

The Paradox of Visual Uniqueness: Managing the Non-Reproducibility of AI-Generated Images in Cross-Media Publishing Workflows

Andriani Goutou¹, Evgenia Pagani¹

¹University of West Attika, Department of Graphic Design and Visual Communication, Hellenic Graphic-Media Research Lab, University of West Attica – GRAPHMEDLAB,

epagani@uniwa.gr

Abstract

Visual consistency is a fundamental principle in Graphic-Media Communication and brand identity management that requires the systematic and reliable reproduction of a consistent visual style and set of thematic elements across diverse media platforms. However, the integration of Generative Artificial Intelligence (GenAI) for image production into premedia workflows introduces a significant methodological paradox: due to the inherent non-deterministic nature of generative image models, each visual output is, in principle, statistically unique. In many production environments, exact reproduction remains difficult due to stochastic model behaviour, model updates, and parameter dependencies.

In response to this constraint, the present study seeks to establish a standardised matrix for cross-media publishers, categorising model performance and offering predictable, repeatable workflows for GenAI model integration. The core objective is to measure the effectiveness of deterministic controls against the inherent stochasticity of the models. Specifically, the paper explores the extent to which deterministic controls can balance stochastic variability in today's AI engines, thus evaluating how these methods can be integrated into existing premedia production workflows to support stable, repeatable brand and design results.

The study employs a three-phase comparative experimental design through multiple generated image sets from the widely adopted commercial and open-source image-generation models (Midjourney, DALL-E 3, Stable Diffusion and Adobe Firefly): (1) defining a stochastic reference point without constraints, (2) applying specific deterministic controls (e.g., seed, style, and character references), and (3) performing a quantitative evaluation of the variability of the resulting images. The research calculates the Structural Similarity Index Measure (SSIM) across multiple generated image sets using Python's SCIKIT-IMAGE to measure visual reproducibility. Furthermore, the methodology evaluates the models' capacity for aspect-ratio adaptation via generative outpainting to assess Cross-Media Flexibility. The image canvas expansion is measured using the Peak Signal-to-Noise Ratio (PSNR), providing a thorough empirical foundation for assessing both the necessity and the performance of hybrid premedia workflows.

The results indicate that, while inherent stochastic variability cannot be eliminated, the integration of hybrid premedia workflows could significantly reduce visual inconsistencies. By pairing AI-generated imagery with conventional image-editing, designers can preserve consistent spatial layout and character appearance across different aspect ratios and distribution channels. In conclusion, the approach ensures that algorithmic variability is managed efficiently, while maintaining visual consistency in professional production environments.

