Printing for Fabrication 2020

Materials, Applications, and Processes

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PRINTING FOR FABRICATION 2020: SCHEDULE AND TECHNICAL PAPERS

DAY 1
MONDAY 19 OCTOBER / TUESDAY 20 OCTOBER

WELCOME AND OPENING KEYNOTE

Session Chair: Ron Askeland, consultant (retired HP Inc.) (US)
19 OCT: 10:00 - 11:00 (NEW YORK) / 15:00 - 16:00 (LONDON) / 23:00 - 00:00 (TOKYO)
Note: this session repeats 19 Oct: 19:00 - 20:00 (New York) and 20 Oct: 00:00 - 01:00 (London) / 08:00 - 09:00 (Tokyo)

Welcome Remarks, *General Chair Teruaki Mitsuya, Ricoh Company Ltd. (Japan)*

The Resilient Hybrid Supply Chain and Digital Manufacturing Future and Present, *Edward D. Davis, HP Inc. (US)**
There are many speculations in the 3D print industry. One such speculation is that a specific 3D process is the right choice for all design requirements and will directly replace injection molding for commodity parts. Supporting this speculation are simplified supply chain arguments that have explained how 3D printing could be used instead of injection molding. In this talk, an explanation of hybrid supply chain models will show how 3D printing could be used to complement injection molding. With the current world situation, adding 3D printing to the part manufacturing toolkit could help mitigate disruptions in supply chains. There will also be an explanation of the longer term Megatrends, and how advances in technology—data analytics/machine learning/artificial intelligence, robotics/automation, 3D printing/functional materials, digital manufacturing, smart devices/industrial IoT, and generative design—will eventually change the world we live in. The talk will present success stories, including designs for preventing the spread of disease.

11:00 (New York) / 16:00 (London) / 00:00 (Tokyo)
Exhibitor Preview: Seiko Instruments Gmbh

19 Oct: 11:05 - 11:30 (New York) / 16:05 - 16:30 (London) / **20 Oct:** 00:05 - 00:30 (Tokyo)
SESSION BREAK
Join the keynote speaker and other attendees in the Zoom Grab-a-Cup Room.

SESSION 1: 3D TECHNOLOGY AND FUNCTIONAL PRINTING

Session Chair: Alvaro J. Rojas, Universidad Autonoma de Occidente (Colombia) / Session Monitor: Susanne Klein, University of the West of England (UK)
19 OCT: 11:30 - 12:25 (NEW YORK) / 16:30 - 17:25 (LONDON) / 20 OCT: 00:30 - 01:25 (TOKYO)

11:30 (New York) / 16:30 (London) / 00:30 (Tokyo)
FOCAL TALK: Fabrication of Magnetic Polymer Nanocomposites Using Inkjet 3D Print Technology, *Madeleine Cannamela[1,2], Jim Stasiak[2], Paul Harmon[3], Thomas Allen[3], and Pallavi Dhagat[1]; [1]Oregon State University, [2]HP Inc., and [3]Nanovox, LLC (US)* **1**
Tailored magnetic nanocomposites have applications ranging from communications technologies to medical devices. Using a novel 3D fabrication technique that combines thermal inkjet and powder bed fusion print technologies, magnetic composites were fabricated by jetting magnetic nanoparticle containing ink into a polymer powder bed and then heat fusing the ink/polymer matrix. The goals were to demonstrate the feasibility of nanocomposite fabrication with controllable magnetic properties by varying the volume fraction of magnetic ink jetted into the polymer as well as to experimentally validate the effective medium theory based model developed to predict the permeability of the composites as a function of its magnetic particle concentration. As expected, magnetic susceptibility and saturation magnetization were seen to increase with the volume fraction of magnetic particles in the composites.

11:55 (New York) / 16:55 (London) / 00:55 (Tokyo)
3D Printing the Woodburytype – Plastic Printing the Plate or Gel Printing the Image? *Damien Leech, Walter Guy, and Susanne Klein, University of the West of England (UK)* **6**
The Woodburytype process is one of the only printing processes capable of producing continuous tone. It is a 2.5D process that produces a textured relief print from a gelatin-based ink that contains no photoactive element and therefore does not degrade with time. Despite all these advantages, the process is time consuming and requires the use of precision equipment to build the printing plate. We explore the initial insights into using more common additive manufacture technologies in producing both a printing plate and in ink characterization for selective deposition of the viscous gelatin ink itself.

12:10 (New York) / 17:10 (London) / 01:10 (Tokyo)
The Use of Low-cost 3D Printing Technology to Develop Fabrication Tools for Clay Profile Extrusion, *Tavs Jorgensen, University of the West of England (UK)* . . . . . **Appendix, A-1**
This paper reports on interim results from ongoing research which investigate how low-cost 3D printing technologies can assist innovation with the clay extrusion process.
The project explores the possibility of using standard filament 3D

**Abstract only; no proceedings paper.*

printers to create key functional tools for the extrusion process, in particular the fabrication of the profiles (dies) that performs the actually shaping of the clay in this fabrication method. The use of 3D filament printers for this application is to date largely unexplored, but holds great potential as a central aspect in establishing low cost and rapid workflows for translating Computer Aided Designs into finished ceramic parts.
The project is funded by a grant form UK Research and Innovation with leading industrial companies as collaborating partners.

19 Oct: 12:25 - 12:55 (New York) / 17:25 - 17:55 (London) /
20 Oct: 01:25 - 01:55 (Tokyo)
SESSION BREAK
Join the keynote speaker and other attendees in the Zoom Grab-a-Cup Room.

SESSION 2: PRINTING RESPONSE TO COVID-19

Session Chair: Ingo Reinhold, Xaar plc (Sweden)
19 OCT: 12:55 - 13:55 (NEW YORK) / 17:55 - 18:55 (LONDON) /
20 OCT: 01:55 - 02:55 (TOKYO)
Note: this session repeats 19 Oct: 21:55 - 22:55 (New York) and 20 Oct: 02:55 - 03:55 (London) / 10:55 - 11:55 (Tokyo)

Printing's Response to COVID-19: A Compilation, *Ron Askeland, consultant, and Cailin Simpson, Outpost Technologies (US)*
This presentation is a compilation of the Printing Industry's response to the pandemic, followed by Q&A. Topics covered will be effects of COVID-19 on the global supply chain; additive manufacturing applications for COVID-19; bioprinting response to COVID-19; and the effects of the pandemic on graphics and textile printing. The COVID-19 responses of government, large and small businesses, and academia are compared. COVID-19 will have a lasting effect on global sourcing, additive manufacturing, in vitro testing and sustainability, with a greater reliance on remote communication.

Break in program to accommodate time zones

WELCOME AND OPENING KEYNOTE (REPRISE)

Session Chair: Ron Askeland, consultant (retired HP Inc.) (US)
19 OCT: 19:00 - 20:00 (NEW YORK) /
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*Abstract only; no proceedings paper.

SESSION 3:
3D TECHNOLOGY AND FUNCTIONAL PRINTING

Session Chair: Cailin Simpson, Outpost Technologies (US) /
Session Monitor: Madeleine Cannamela, HP Inc. (US)
19 OCT: 20:30 - 21:25 (NEW YORK) /
20 OCT: 01:30 - 02:25 (LONDON) / 09:30 - 10:25 (TOKYO)

20:30 (New York) /
01:30 (London) / 09:30 (Tokyo)
FOCAL TALK: 3D Printing Technique to Make Information inside an Object Rewritable: Effect of Amount of Filament on Readability, *Piyarat Silapasuphakornwong[1], Hideyuki Torii[1], Masahiro Suzuki[2], and Kazutake Uehira[1]; [1]Kanagawa Institute of Technology and [2]Tokiwa University (Japan)*. **12**
This paper presents a technique for embedding information into a 3D object. The technique can rewrite the information non-destructively. Information can be rewritten into the object using magnetization and demagnetization from the outside of the fabricated object. We are studying the factors that can make more clear readability and effective rewritability in embedding data into 3D objects. One factor is the amount of magnetic filament that we use for representing the information in each position. We found that the strength of the magnetic field varies in accordance with the amount of filament. In this way, we can control the size, frequency, and capacity of future embedded information.

20:55 (New York) /
01:55 (London) / 09:55 (Tokyo)
JIST-First: Fabrication of 3D Temperature Sensor Using Magnetostrictive Inkjet Printhead, *Young-Woo Park and Myounggyu Noh, Chungnam National University (South Korea)*. **17**
Recently, the three-dimensional (3D) printing technique has received much attention for the shape forming and manufacturing. In this work, for the first time, we present the fabrication of inkjet printed 3-diamentional (3D) low cost temperature sensor on a 3D shaped thermoplastic substrate suitable for packaging, flexible electronics, and other printed application. The design, fabrication, and testing of a 3D printed temperature sensor is presented. The sensor pattern is designed using computer-aided design (CAD) program and fabricated by inkjet printing with a drop-on-demand (DoD) using magnetostrictive inkjet printhead at room temperature. The sensing pattern is printed using commercially available conductive silver nanoparticles ink (AgNPs). The moving speed of 90 mm/min is chosen to print the sensor pattern. The inkjet printed temperature sensor is demonstrated and characterized with good electrical properties, showing a good sensitivity and linearity. The results indicate that the 3D inkjet printing technology may have a great applied potential in sensor fabrication.

21:10 (New York) /
02:10 (London) / 10:10 (Tokyo)
Novel Method to Drive new High Temp FDM Hotend, *Hideo Taniguchi, KHR Center (Japan) and Jiro Oi, KHR Center (US)*. **22**
In recent years, some FDM 3D printer manufacturing companies succeeded in going beyond hotend temperature of 400°C to take advantage of new highly durable materials known as "super engineering plastic". To accomplish the high temperature operation, the de facto industry standard is to employ the high-powered heater and liquid cooling system for their machines.

A new high temperature hotend based on completely different concept has been developed which does not require conventional cooling system to achieve 500°C level temperature. However, it is almost at the high end of the FDM processing temperature limit and extreme care was taken to develop the compact, self-contained, and eco-friendly and heating-on-demand hotend. We had high hopes for the new hotend not only from the industry viewpoint, but also from contribution to minimize global warming.

However, we found a product life issue intermittently with the newly developed hotend. This report is on a novel approach to remedy the problem to extend the new hotend life longer, contributing to longevity of the high temperatures and stable operation with high reliability for 3D printing.

19 Oct: 21:25 - 21:55 (New York) /
20 Oct: 2:25 - 02:55 (London) / 10:25 - 10:55 (Tokyo)
SESSION BREAK
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SESSION 4:
PRINTING RESPONSE TO COVID-19

Session Chair: Steve Simske, Colorado State University (US)
19 OCT: 21:55 - 22:55 (NEW YORK) /
20 OCT: 02:55 - 03:55 (LONDON) / 10:55 - 11:55 (TOKYO)
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DAY 2
TUESDAY 20 OCTOBER / WEDNESDAY 21 OCTOBER

KEYNOTE II

Session Chair: Susanne Klein, University of the West of England (UK) /
Session Monitor: Neil Chilton, Printed Electronics, Ltd. (UK)
20 OCT: 04:00 - 05:00 (NEW YORK) / 09:00 - 10:00 (LONDON) / 17:00 - 18:00 (TOKYO)
Note: this session repeats 20 Oct: 10:00 - 11:00 (New York) / 15:00 - 16:00 (London) / 23:00 - 00:00 (Tokyo)

Remarks, *Program Chair Nobuyuki Nakayama, Fuji Xerox Co. (Japan)*

The Art of the Maker—Craft, Design, and Technology in the 21st Century, *Carinna Parraman, University of the West of England, Bristol (UK)* **26**
Invention, innovation, and insight are keywords for any technologist and designer working in the academic or commercial sector. In the twenty-first century, a wealth of new and emerging materials, alongside digital methods for the manufacture of products and services are transforming and enhancing our lives. But there are also the age-old techniques and crafts traditions that demonstrate fundamental benchmarks in material culture that are the foundation for high-quality printing and fabrication today and in the future. And without these benchmarks in quality, we have no assurance as to diversity and quality over the ubiquitous and inadequate. Exploring the future of printing and fabrication, new ways of thinking and working, alongside traditional methods of making, this paper sets out the shifting field of Homo Faber and the human condition, and how digital technologies are transforming craft and design. The presentation includes multi-disciplinary research undertaken at The Centre for Fine Print Research (CFPR). Researchers are exploring and researching new transformative technologies, working and communicating across disciplines and industries. The Centre is at the forefront of craft and digital fabrication, combining knowledge of traditional and new tools, sustainable materials as part of the circular economy, robotics for practice-led design, exploring physical and tactile surfaces for human engagement, and historic methods for cultural reconstruction.

Break in program to accommodate time zones

KEYNOTE II (REPRISE)

Session Chair: Susanne Klein, University of the West of England (UK) / Session Monitor: Alvaro J. Rojas, Universidad Autonoma de Occidente (Colombia)
20 OCT: 10:00 - 11:00 (NEW YORK) / 15:00 - 16:00 (LONDON) / 23:00 - 00:00 (TOKYO)
Note: this talk also occurs 20 Oct: 04:00 - 05:00 (New York) / 09:00 - 10:00 (London) / 17:00 - 18:00 (Tokyo)

Remarks, *Executive Program Chair Ron Askeland, consultant (retired HP Inc.) (US)*

The Art of the Maker – Craft, Design, and Technology in the 21st Century, *Carinna Parraman, University of the West of England, Bristol (UK)* **26**
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20 Oct: 11:00 - 11:30 (New York) / 16:00 - 16:30 (London) / 00:00 - 00:30 (Tokyo)
SESSION BREAK
Join the keynote speaker and other attendees in the Zoom Grab-a-Cup Room.

SESSION 5:
INKS AND INK/SUBSTRATES INTERACTION

Session Chair: Yubai Bi, HP Inc. (US) / Session Monitor: Mark Bale, DoDxAct Ltd. (UK)
20 OCT: 11:30 - 12:15 (NEW YORK) / 16:30 - 17:15 (LONDON) /
21 OCT: 00:30 - 01:15 (TOKYO)

11:30 (New York) / 16:30 (London) /
00:30 (Tokyo)

Differentiating Digital Printing through Physical and Chemical Analysis, *Ana Sousa[1], Jon Kellar[1], Grant Crawford[1], Steven Simske[2], and Jacob Petersen[1]; [1]South Dakota School of Mines and Technology and [2]Colorado State University (US)* **32**

Over the past decade, the trade of counterfeit goods has increased. This has been enabled by advancements in low-cost digital printing methods (e.g., inkjet and laserjet) that are an asset for counterfeit production methods. However, each printing method produces characteristic printed features that can be used to identify not only the printing method, but also, uniquely identify the specific make and model of printer. This knowledge can be used for determination of whether or not the analyzed item is counterfeit. During the first phase of this research, chemical and physical analyses were performed on printed documents and ink samples for two types of digital printing: inkjet and laserjet. The results showed that it is possible to identify the digital method used to print a document by its unique features. Physical analysis revealed that the laserjet prints have a higher image quality characterized by sharper feature edge quality, brighter image area, and a thicker ink layer (10 micron average thickness) than in inkjet documents. Chemical analysis showed that the inkjet and laserjet inks could easily be distinguished by identifying the various ink components. Ink jet inks included (among others) water and ethylene glycol while laserjet inks presented styrene, methacrylate, and sulfide compounds.

11:45 (New York) / 16:45 (London) /
00:45 (Tokyo)

Influences on Spreading of Inkjet Inks on Coated Cardboards, *Sandra Rosalen and Johannes Backhaus, Bergische Universität Wuppertal (Germany)* **37**

Well-known models to explain the interaction between liquids and surfaces include parameters as fluid viscosity, surface tension, and density. Regarding the surface, the properties as porosity and roughness, and surface energy are relevant. In Inkjet printing this interaction can be influenced also by ink injection parameters. Several studies were published in the last years using these models to analyze different substrates for Inkjet as plain and Inkjet papers. The experiments here focus on this interaction but between Inkjet inks and coated cardboards. The main findings are related to an opposite ink spreading speed of pigment and dye inks with increasing of ink surface tension and viscosity. It is also demonstrated a high correlation between spreading speed and total surface energy of the cardboards.

12:00 (New York) / 17:00 (London) /
01:00 (Tokyo)

Micron-scale Liquid Engineering for Polymer Patterning, *Qingxin Zhang and Ronan Daly, University of Cambridge (UK).* . . . **Appendix, A-3**

Microporous polymer structures have a rich history of applications from insulation and impact absorption to superhydrophobic coatings, controlled drug release materials, biological scaffolds and photonic materials. In 1994 a self-organisation technique was reported to trap and self-organise condensed water droplets at a solution surface and then imprint their shape directly into a polymer film. This operates at ambient conditions and can be controlled to form a wide range of porous structures and surface functionalities. However, there are significant manufacturing challenges that have prevented this technique from reaching the market. Our research tackles this problem by combining top-down techniques for precise liquid deposition (i.e. inkjet printing) with the same bottom-up self-assembly processes (at microscale by ordering drops and nanoscale by encapsulating materials in drops). This research aims firstly to control and simplify the system to understand the force balances and interfacial phenomena by observing the impact behaviour of droplets generated by inkjet printing and secondly to deliver a new, simple and scalable engineering solution to translate this technique to the manufacturing of materials with controlled surface properties.

20 Oct: 12:15 - 12:45 (New York) / 17:15 - 17:45 (London) /
21 Oct: 01:15 - 01:45 (Tokyo)
SESSION BREAK

Join the keynote speaker and other attendees in the Zoom Grab-a-Cup Room.

SESSION 6:
PRINTING TECHNOLOGY

Session Chair: Steve Korol, Evolutionary Technology LLC (US) /
Session Monitor: Steve Simske, Colorado State University (US)
20 OCT: 12:45 - 13:15 (NEW YORK) / 17:45 - 18:15 (LONDON) /
21 OCT: 01:45 - 02:15 (TOKYO)

12:45 (New York) / 17:45 (London) /
01:45 (Tokyo)

JIST-First: Deflecting the Issue: The Origin of Nanoscale Material Build-up in Continuous Inkjet Printing, *Maria Cristina Rodriguez-Rivero[1], Julian Philpott[2], Alex Hann[2], Josephine Harries[2], and Ronan Daly[1]; [1]University of Cambridge and [2]Domino UK Ltd. (UK)* **44**

Continuous Inkjet (CIJ) printing relies on steering charged droplets accurately to the surface with electric fields. A vital component is the set of deflecting electrodes within the printhead that create these fields. Unwanted deposition of ink on the electrodes, known as build-up, is a concern for operators because it modifies the applied electric field, affects long-term reliability and requires manual intervention, but is not widely reported or explored. Here we report a laser-based high-speed visualisation technique to observe build-up and show it stems from small satellite droplets that break off from the main printed drops. We characterise the material build-up and reveal its nanoscale particulate nature. Combining the tracking with characterisation allows us to quantify the charge-to-mass ratio of these droplets. This study provides a route to

understand the build-up phenomenon and will enable optimisation of the printing conditions and printing reliability.

13:00 (New York) / 18:00 (London) / 02:00 (Tokyo)

Direct-to-Shape: Accelerating Printhead Performance, *Renzo Trip and Angus Condie, Xaar plc (UK), and Werner Zapka, WZA-Consulting (Sweden)* . . . . . **Appendix, A-5**

Inkjet printheads are typically mounted horizontally, whereby droplets are ejected downwards. In various applications the printhead is operated in `skyscraper´-mode, whereby the printhead is mounted vertically. As a result of the printhead orientation the static nozzle pressure varies across the printhead. A similar variation in pressure arises when a printhead is being accelerated due to the inertia of the ink.

In the present study the effect of orientation and acceleration on jetting performance of a Xaar 1003 is investigated by mounting the printhead on a robotic arm. It can be shown that the printhead remains operational in any orientation and when being accelerated up to 10 m/s2. The reliability of the printhead is ascribed to the large meniscus pressure window and the self-recovering ability.

SESSION 7: LATE BREAKING NEWS EUROPE/AMERICAS

Session Chair: Werner Zapka, WZA Consulting (Sweden) / Session Monitor: Jim Stasiak, HP Inc. (US)

20 OCT: 13:15 - 14:00 (NEW YORK) / 18:15 - 19:00 (LONDON) / 21 OCT: 02:15 - 03:00 (TOKYO)

Presenters:

Carl Yee, BluePlanet Ink (US) on 'disappearing ink - paper recycles itself'... for the benefit of reduced paper waste

Sasan Gooran, Univeristy of Linkoeping (Sweden) on using hybrid halftoning for increase of image sharpness or reducing the appearance of surface roughness

Graham Tweedale, Xaar (UK) on the new roadmap for inkjet

Christoph Kaiser and Florian Ullrich, Innovation Labs Heidelberg (Germany) on printed electronics for occlusion control

Break in program to accommodate time zones

SESSION 8: INKS AND INK/SUBSTRATES INTERACTION

Session Chair: Atsushi Tomotake, Konica Minolta, Inc. (Japan) / Session Monitor: Yubai Bi HP Inc. (US)

20 OCT: 19:00 - 19:55 (NEW YORK) / 21 OCT: 00:00 - 00:55 (LONDON) / 08:00 - 08:55 (TOKYO)

Remarks, *General Chair Teruaki Mitsuya, Ricoh Company, Ltd (Japan)*

19:10 (New York) / 00:10 (London) / 08:10 (Tokyo)

Wetting Simulations in Surface Energy Confined Subpixels for Inkjet Printed Display Applications, *Dong-Youn Shin, Pukyong National University (South Korea).* . . . . . **Appendix, A-6**

Inkjet printing has been deemed as a viable manufacturing tool for the productions of OLED and QD-OLED TVs. It requires to precisely deposit an exact amount of OLED or QD ink in 99 million subpixels. The surface energies of bank and glass are required to be accurately tuned for preventing the intermixing of inks across adjacent subpixels. An optimized shape of subpixels for natural ink flow is also required to be considered because the conventional geometric shape of subpixels designed for photolithographic processes is not valid for inkjet printing. In this contribution, the minimum and maximum contact angles of ink against bank and glass are investigated and then the influence of the geometric shape of a subpixel on ink filling will be discussed.

19:25 (New York) / 00:25 (London) / 08:25 (Tokyo)

Self-erasing Ink: Paper Doesn't have to be Disposable, *Carl Yee, Blue Planet Ink (US).* . . . . . **Appendix, A-8**

Printing delivers near archival document lifespans. Yet for the last 20 years most printed documents have been needed only temporarily. In the digital age printed documents are created, transmitted, and stored electronically. Paper is merely the disposable display device.

Paper is the largest contributor to the carbon footprint of printing and copying. Paper consumption can be radically reduced by reusing paper. The productivity benefits of printing can be retained while reducing waste.

Paper can be reused when the printed image is removed. This can be done with a self-erasing inkjet ink. The ink reacts with air to change pH and de-colorize, restoring the paper to its un-printed state. The erasing functionality is contained within the ink itself; no additional printing or erasing technology is required.

19:40 (New York) / 00:40 (London) / 08:40 (Tokyo)

JIST-First: Effects of the Thickness of Boundary Layer on Droplet's Evaporation Rate, *Panus Jongleartrakull[1], Kazuyoshi Fushinobu[1], and Masami Kadonaga[1,2]; [1]Tokyo Institute of Technology and [2]Ricoh Company, Ltd. (Japan)* **54**

Inkjet printing`s market has been growing for several years. Evaporation rate of droplet was explained relating to the boundary layer and condition near the droplet`s surface. However, no experimental result has been obtained. This study aims to investigate the boundary layer of ethanol-water mixture droplet and its effect on the evaporation rate by Z-type Schlieren visualization. Single and double droplet were tested and compared in order to identify the effect of the second droplet on the

**Abstract only; no proceedings paper.*

average and instantaneous evaporation rate. Double droplet`s lifetime was found to be longer than single. It is indicated that larger evaporation region formed on the top of the droplet means higher instantaneous evaporation rate. Boundary layer was found to be larger as ethanol`s concentration increased. Furthermore, larger evaporation region was found in higher ethanol concentration case and that described faster evaporation found in higher ethanol concentration.

20 Oct: 19:55 - 20:20 (New York) /
21 Oct: 00:55 - 01:20 (London) / 08:55 - 09:20 (Tokyo)
SESSION BREAK

Join the keynote speaker and other attendees in the Zoom Grab-a-Cup Room.

SESSION 9: PRINTING TECHNOLOGY

Session Chair: Katrinia Donovan, South Dakota School of Mines and Technology (US) / Session Monitor: Kye-Si Kwon, Soonchunhyang University (South Korea)
20 OCT: 20:20 - 21:15 (NEW YORK) /
21 OCT: 01:20 - 02:15 (LONDON) / 09:20 - 10:15 (TOKYO)

20:20 (New York) /
01:20 (London) / 09:20 (Tokyo)
FOCAL TALK: Dynamic Imaging Solution, *Chunghui Kuo, Eastman Kodak Company (US)* **65**
The basic economic principle dictates that productivity improvement is one of the main driving forces for raising the living standard of the general public and maximizing companies' profit margin. By replacing analog devices with their digital counterparts, the last digital revolution has made huge contribution in boosting labor productivity annually despite the reduction in averaged working hours. However, the labor productivity growth rate has dropped to the lowest level since the Great Recession in 2008. Recognizing the long-term sustainability challenges of the current economic development, a new societal paradigm has emerged where artificial intelligence and connected devices take over well-defined tasks to achieving economies of scale and empowering people to innovate and create value. Being a form of mass customization manufacturing process, a dynamic imaging solution is proposed in an electrophotographic printing system with computational calibration capability in the spatial and tonal domains when requested, which could serve as an important enabling technology for the vision of autonomous printing.

20:45 (New York) /
01:45 (London) / 09:45 (Tokyo)
Functional Decorative Printing with On-demand Melt Thermal Transfer Printer, *Kenta Suzuki, Masahito Watanabe, Hiroshi Kobayashi, and Hirotoshi Terao, Alps Alpine Co., Ltd. (Japan).* . . **Appendix, A-10**
Combining on-demand thermal transfer technology with the capacitive sensor, we are developing a touch device capable of stealth illuminating in addition to reproducing the tactile sensation of wood grain. Taking advantage of the characteristics of dry thin film ink of thermal transfer printing, a realistic texture feeling is reproduced by printing multilayer with high precision. In addition, since the ink is thin and has good light transmission, stealth illumination is possible. Further, in the thermal transfer, since the metal vapor deposition ink can be printed, a seamless expression such as a metal-grain gradation is possible. We will report on the status of studies on these functional decorative prints.

21:00 (New York) /
02:00 (London) / 10:00 (Tokyo)
An Efficiency Electrospray Method for Hydrophobic Coating, *Kye-Si Kwon, Md. Khalilur Rahman, and Soobin Oh, Soonchunhyang University (South Korea)* . . . . . **Appendix, A-12**
Many electronic devices require highly insulating materials as substrates. When using highly insulating substrates, electrostatic charges on the substrate often lead to low manufacturing yield or even damage of electronic components. In case of electrospray deposition, charged droplets are used for deposition of functional materials on substrates. If the charges on the substrate are not treated properly, the accumulated charges produce repulsive force against incoming charged droplets, adversely affecting the film uniformity and the deposition rate. In this study, we propose a new electrospray method that is universally effective for various substrates with different conductivities by adjusting the AC voltage on the substrate holder instead of the conventional approach of grounding the holder. As a demonstration, super-hydrophobic coatings were shown to be uniformly deposited via electrospray on highly insulating substrates, such as printed circuit board (PCB).

SESSION 10: LATE BREAKING NEWS ASIA/AMERICAS

Session Chair: Masahiko Fujii, Fuji Xerox Co., Ltd. (Japan) / Session Chair: Steve Smske, Colorado State University (US)
20 OCT: 21:15 - 22:00 (NEW YORK) /
21 OCT: 02:15 - 03:00 (LONDON) / 10:15 - 11:00 (TOKYO)

An Open Form Platform that Enables New Aapplications of Inkjet, *Sinri Sakai, Yamagata University Ink Jet Development Center (Japan)*
An Inkjet Flex PCB Production Line that Contributes to the Sustainability of our Planet and Business, *Masaaki Sugimoto, Elephantech Inc. (Japan)*

**Abstract only; no proceedings paper.*

DAY 3
WEDNESDAY 21 OCTOBER / THURSDAY 22 OCTOBER

CLOSING KEYNOTE

Session Chair: Ingo Reinhold, Xaar plc (Sweden) /Session Monitor: Neil Chilton, Printed Electronics, Ltd. (UK)

21 OCT: 04:00 - 05:00 (NEW YORK) / 09:00 - 10:00 (LONDON) / 17:00 - 18:00 (TOKYO)

Note: this session repeats 21 Oct: 10:00 - 11:00 (New York) / 15:00 - 16:00 (London) / 23:00 - 00:00 (Tokyo)

Remarks, *General Chair Teruaki Mitsuya, Ricoh Company, Ltd (Japan)*

Fundamental Fluid Dynamics Challenges in Inkjet Printing,
*Herman Wijshoff, Canon Production Printing and Eindhoven University of Technology (the Netherlands)**

To comply with the increasing and diverging requirements for today's inkjet technology, a fundamental understanding of the underlying processes is very important. It is essential that decisions can be made based on theoretical, numerical, or experimental models as a firm basis for further product development. At Canon Production Printing, we develop the experimental techniques, numerical codes, and theoretical frameworks in close collaboration with academic research groups in the research program fundamental fluid dynamics challenges in inkjet printing. This talk presents some highlights of this research program, e.g., the quantitative detection of misting down to 1 fl. drops with a laser induced fluorescence technique, evaporation induced segregation processes within a single sessile drop with confocal laser microscopy, and the migration of drops on a thin liquid layer with digital holographic cameras, supported by numerical simulations down to the molecular scale and theoretical evaluations.

Break in program to accommodate time zones

CLOSING KEYNOTE (REPRISE)

Session Chair: Ingo Xaar plc (Sweden) /Session Monitor: Christina Rodriguez-Rivero, University of Cambridge (UK)

21 OCT: 10:00 - 11:00 (NEW YORK) / 15:00 - 16:00 (LONDON) / 23:00 - 00:00 (TOKYO)

Note: this talk also occurs 21 Oct: 04:00 - 05:00 (New York) / 09:00 - 10:00 (London) / 17:00 - 18:00 (Tokyo)

Remarks, *Executive Program Chair Ron Askeland, consultant (retired HP Inc.) (US)*

Fundamental Fluid Dynamics Challenges in Inkjet Printing,
*Herman Wijshoff, Canon Production Printing and Eindhoven University of Technology (the Netherlands)**

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*Abstract only; no proceedings paper.

21 Oct: 11:00 - 11:30 (New York) / 16:00 - 16:30 (London) /
22 Oct: 00:00 - 00:30 (Tokyo)
SESSION BREAK

Join the keynote speaker and other attendees in the Zoom Grab-a-Cup Room.

SESSION 11: IMAGING AND MODELING

Session Chair: Christina Rodriguez-Rivero, University of Cambridge (UK) /
Session Monitor: Chung-Hui Kuo, Eastman Kodak Company (US)

21 OCT: 11:30 - 12:40 (NEW YORK) / 16:30 - 17:40 (LONDON) / 22 OCT: 00:30 - 01:40 (TOKYO)

11:30 (New York) / 16:30 (London) /
00:30 (Tokyo)

3D Halftoning based on Iterative Method Controlling Dot Placement,
Fereshteh Abedini, Sasan Gooran, and Daniel Nyström, Linköping University (Sweden) **69**

Realistic appearance reproduction is of great importance in 3D printing's applications. Halftoning as a necessary process in printing has a great impact on creating visually pleasant appearance. In this article, we study the aspects of adapting and applying Iterative Method Controlling Dot Placement (IMCDP) to halftone three-dimensional surfaces. Our main goal is to extend the 2D algorithm to a 3D halftoning approach with minor modifications. The results show high-quality reproduction for all gray tones. The 3D halftoning algorithm is not only free of undesirable artifacts, it also produces fully symmetric and wellformed halftone structures even in highlight and shadow regions.

11:45 (New York) / 16:45 (London) / 00:45 (Tokyo)

FOCAL TALK: 3D Surface Structures and 3D Halftoning, *Sasan Gooran and Fereshteh Abedini, Linköping University (Sweden)* **75**

As 3D printing is becoming increasingly popular, the demand for high quality surface reproduction is also increasing. Like in 2D printing, halftoning plays an important role in the quality of the surface reproduction. Developing advanced 3D halftoning methods for 3D printing and adapting them to the structure of the surface is therefore essential for improving surface reproduction quality. In this paper, an extension of an iterative 2D halftoning method to 3D is used to apply different halftone structures on 3D surfaces. The results show that using different halftones based on the 3D geometrical structure of the surface and/or the viewing angle in combination with the structure of the texture being mapped on the surface can potentially improve the quality of the appearance of 3D surfaces.

12:10 (New York) / 17:10 (London) /
01:10 (Tokyo)

The Reconstruction of the Appearance of the Acancéh Frieze by 2.5 Printing, *Susanne Klein, Abigail Trujillo Vazquez, Xavi Aure Calvet, and Carinna Parraman, University of the West of England (UK)* **81**

The aim of the project is to reconstruct the appearance of the Maya frieze of the Palace of the Stuccoes in Acancéh Yucatán, dating from c. 350 BC to AD 850. The frieze itself is destroyed by now but was documented by Adela Breton in 1907. Her watercolours on drafting linen and few black and white photographs taken by her at the same time are the basis of 2.5D prints which reconstruct the appearance of the frieze. After analyzing the colours recorded in the watercolours and the shadows in her photographs, we employ Woodburytype and the combination of photogravure, relief printing, and embossing to generate a print which comes close to the optical and haptic appearance of the original.

12:25 (New York) / 17:25 (London) /
01:25 (Tokyo)

Modelling Additive Manufacturing by Two-Photon Polymerisation, *Mykyta Chubynsky[1], Qin Hu[2], Gustavo Trindade[2], Richard Hague[2], Derek Irvine[2], Clive Roberts[2], Christopher Tuck[2], Lyudmila Turyanska[2], Ricky Wildman[2], and James Sprittles[1];[1]University of Warwick and [2]University of Nottingham (UK).* . . . . . **Appendix, A-14**

Two-photon polymerisation (2PP) is an additive manufacturing technique allowing fabrication of complex 3D objects with submicron features using laser light. For high-quality fabrication, laser power needs to stay within a relatively narrow range (the processing window) that depends on both the material and the fabrication scenario. When an object is produced by scanning parallel lines in 3D, the processing window depends on the distances between the lines in different directions, the number of times each line is scanned, and the scanning speed. We find that for the upper boundary of the processing window, the multiple parameters can be reduced to a single variable. To understand and extend this result, we have started to develop a model taking into account chemical and physical processes that occur during 2PP.

21 Oct: 12:40 - 13:10 (New York) / 17:40 - 18:10 (London) /
22 Oct: 01:40 - 02:10 (Tokyo)

SESSION BREAK

Join the keynote speaker and other attendees in the Zoom Grab-a-Cup Room.

SESSION 12:
PRINTED ELECTRONICS

Session Chair: Jim Stasiak, HP Inc. (US) / Session Monitor: Ingo Reinhold, Xaar plc (Sweden)

21 OCT: 13:10 - 13:50 (NEW YORK) / 18:10 - 18:50 (LONDON) /
22 OCT: 02:10 - 02:50 (TOKYO)

13:10 (New York) / 18:10 (London) /
02:10 (Tokyo)

Printed Arrays of Sensors based on Multiwall Carbon Nanotubes (MWCNTs), *Tatiana Zubkova, Zheng Hu, Jose Roberto Bautista-Quijano, Dhivakar Rajendran, Rajarajan Ramalingame, Olfa Kanoun, and Reinhard R. Baumann, Technische Universität Chemnitz (Germany)* . . **Appendix, A-16**

One of the challenges in the development of Smart Wearables is the integration of sensors for the reliable monitoring of signals / data of the human body. A promising material basis for sensor applications are functionalized multiwall carbon nanotubes (MWCNTs) [1-3]. These materials can be processed as a liquid and therefor printing technologies like screen and inkjet printing qualify for the manufacturing. Especially the digital inkjet technology allows a high degree of flexible design of sensors, transistors, and actuators.

In this approach, array of sensors based on the characterized MWCNT dispersion has been successfully fabricated on polymer substrates. The fabrication was done in several steps including screen printing of array of electrodes, laser perforation and inkjet printing of sensing material, and a barrier layer. The actual experimental results demonstrate the suitability of the fabricated array for temperature distribution sensing. A high quality, electrical cross-talk free temperature detection in the array is achieved by an embedded solution using zero potential circuit with necessary calibration approach.

13:25 (New York) /18:25 (London) /
02:25 (Tokyo)

Interaction of an Inkjet Printed Conductive Ink with Textile Substrates, *Zixin Wang, Brian Derby, and Tristan Lowe, University of Manchester (UK)* . . . . . **Appendix, A-18**

X-ray tomographic reconstruction reveals that the distribution of Ag after inkjet printing and sintering a nanoparticle conducting ink on a woven polyester textile substrate is strongly controlled by the fiber surface properties and fabric architecture. Capillarity confines the transport of the ink predominantly within the warp or weft yarns of the fabric and there is little transport of ink between the yarns. Changing the fibre surface energy through the Scotchgard treatment leads to an increase in contact angle, reducing ink transport along the fibres, and an increase in conductance. A similar effect is seen when printed drop spacing is reduced, increasing the local Ag concentration. Electrical conductivity is strongly influenced by the fibre density in each yarn direction and, in this case, the different densities lead to different electrical conductance values. Through the use of image segmentation, it is possible to identify a low level of electrical interconnection between the warp and weft yarns. Conductivity within a yarn is shown to depend on Ag concentration via a percolation mechanism and this is confirmed by a simple model relating the volume of the largest interconnected Ag object present to conductance. These results illustrate the complexity of the interaction between conductive inks and fibrous substrates and that concepts, such as sheet resistance, used to characterize printed conductors on solid substrates are not applicable to textile substrates.

13:40 (New York) / 18:40 (London) /
02:40 (Tokyo)

Closing Remarks, *Executive Program Chair Ron Askeland, consultant (retired HP Inc.) (US)*

Break in program to accommodate time zones

**Abstract only; no proceedings paper.*

SESSION 13:
IMAGING AND MODELING

Session Chair: Jaynta Panditaratne, HP Inc. (US) / Session Monitor: Takeshi Menjo, ISJ (Japan)

21 OCT: 19:00 - 20:35 (NEW YORK) /
22 OCT: 00:00 - 01:35 (LONDON) / 08:00 - 09:35 (TOKYO)

Remarks, *General Chair Teruaki Mitsuya, Ricoh Company, Ltd (Japan)*

19:10 (New York) /
00:10 (London) / 08:10 (Tokyo)

FOCAL TALK: Probabilistic Motion Inference for Fused Filament Fabrication, *Francisco Mercado Rivera, Alvaro Rojas Arciniegas, and Victor Romero Cano, Universidad Autónoma de Occidente (Colombia)* **85**

Additive manufacturing techniques have been the focus of studies and technological advances in recent years, obtaining the capability to fabricate pieces with complex geometries easily, rapid and with high precision, allowing the use of different materials, the appearance of new techniques, and a range of applications beyond prototyping. However, Additive Manufacturing techniques are still affected by some deficiencies and challenges such as the absence of sensing and control during the fabrication process that would result in a more reliable process and printed part. This paper shows the development of an inference process using probabilistic graphical models, in order to track the motion of the extrusion nozzle during the printing process using linear encoders.

19:35 (New York) /
00:35 (London) / 08:35 (Tokyo)

JIST-First: Tone Curve Compensation of Multiple Color Halftoning Screen Printing for Heterogeneous Fabrics, *Chao-Lung Yang, Chi-Hao Chien, and Yen-Ping Lin, National Taiwan University of Science and Technology, and Chi-Hsun Chien, Ample Ace Co., Ltd (Taiwan)* **92**

For mass production, multiple color halftoning screen printing (MCHSP) can be considered as the alternative textile printing technology when vivid color gradation is needed and cost for digital printing is concerned. Essentially, MCHSP utilizes the same equipment as traditional screen printing to print overlapped multiple color gradation under halftoning patterns by applying the dedicated treatments on color separation and calibration. In order to ensure the color quality, the equipment calibration and tone curve compensation are required to compensate the variables from equipment setup and heterogeneous fabrics. In this research, we provided the procedure of tone curve compensation to alleviate the discrepancy from heterogeneous fabrics. The experimental result based on 55 samples of 44 different fabrics shows the compensation effectiveness and reveal the distribution of average compensation percentage across fabrics.

19:50 (New York) /
00:50 (London) / 08:50 (Tokyo)

Study of an Intelligible and Quantitative Index to Clarify Required Gloss Impression, *Natsuko Minegishi, Masahiro Onodera, and Dai Suwama, Konica Minolta, Inc. (Japan)* **102**

This study focused on suggesting an intelligible index for evaluating gloss degrees of printed images. Psychophysical evaluation of image-clarity was performed for various kinds of paper surfaces. Additionally, cluster analysis was performed for classifying the evaluated values. As results, we found that image-clarity on a printed image and paper can be classified into 4 main categories, and quantitatively clarified that 3 main kinds of paper can be the intelligible index to describe gloss degrees of printed image. Furthermore, extent, in which observers cannot recognize differences of image-clarity, has been shown, and this result is expected to be a useful guide for determining conditions of printers from gloss quality point of view.

20:05 (New York) /
01:05 (London) / 09:05 (Tokyo)

Predicting Response of Printed Potentiometric Nitrate Sensors Using Image based Machine Learning, *Qingyu Yang, Kerry Maize, Xin Jin, Hongjie Jiang, Muhammad Alam, Rahim Rahimi, George Chiu, Ali Shakouri, and Jan Allebach, Purdue University (US)* **108**

Solid-contact nitrate sensors have wide applications in agriculture. In manufacturing, fabrication is an essential step and strongly affects the sensor performance. We focus on controlling the fabrication process to develop an economical thin-film nitrate sensor with an ion-selective membrane (ISM). However, direct long-time measurement of sensor performance for monitoring fabrication is expensive and costs human labor. Thus, in this work, we propose an automatic system to predict the temporal potentiometric response based on non-contact images acquired in real time. Our prediction systems are generated by exploiting image-processing techniques and machine learning approaches. To improve the prediction accuracy, we also fuse manufacturing factors to the image inputs. The comparison of prediction performance with different inputs also helps us to understand their effects on the fabrication process.

20:20 (New York) / 01:20 (London) / 09:20 (Tokyo)

JIST-First: Impact of Geometric Features on Color Similarity Perception of Displayed 3D Tablets, *Jiangping Yuan[1], Hua Li[2], Baohui Xu[2], and Guangxue Chen[1]; [1]South China University of Technology and [2]Yuncheng University (China)* **114**

To explore effects of geometric features on color similarity perception of displayed 3D tablets designed by color 3D modeling techniques or printed by color 3D printing techniques, two subjective similarity scaling tasks were conducted for color tablets with four shape features (circular-, oval-, triangular columnar-, and rounded cuboid-shaped) and four notch features (straight V-, straight U-, crisscross V-, and crisscross U- shaped) displayed on the calibrated monitor using nine-level category judgement method. Invited observers were asked to classify each specific sample in tablet groups using six surface colors (aqua blue, bright green, pink, orange yellow, bright red, and silvery white), and recorded all perceived similarity values compared to original samples successively. A fact that the similarity perception of tested tablets was inapparently affected by given shape features and notch features, should judge by a flexible interval rather than a fixed color difference. This research provides a practical insight into vision visualization of color similarity perception for displayed personalized tablets to achieve further precision medicine.

21 Oct: 20:35 - 21:05 (New York)
22 Oct: 01:35 - 02:05 (London) / 09:35 - 10:05 (Tokyo)

SESSION BREAK

Join the keynote speaker and other attendees in the Zoom Grab-a-Cup Room.

**Abstract only; no proceedings paper.*

SESSION 14:
PRINTED ELECTRONICS

Session Chair: Makoto Omodani, Tokai University (Japan) / Session Monitor: Cailin Simpson, Outpost Technologies (US)

21 OCT: 21:10 – 22:00 (NEW YORK) /
22 OCT: 02:10 – 03:00 (LONDON) / 10:10 – 11:00 (TOKYO)

21:10 (New York) /
02:10 (London) / 10:10 (Tokyo)

FOCAL TALK: Additive-free Aqueous MXene Inks for Printed Electronics, *Simge Uzun[1], Genevieve Dion[1], Ron Askeland[2], and Yury Gogotsi[1], [1]Drexel University and [2]HP Inc.**

Significant breakthroughs have been made in the development of wearable technologies by integrating functional nanomaterials into fiber-, yarn-, and fabric-devices. Due to their versatile chemistry and facile processability, two-dimensional (2D) transition metal carbides and/or nitrides, i.e. MXenes, are promising candidates for achieving the next generation of textile-based devices such as batteries, capacitors, antennas, sensors, etc. This talk provides an overview of our collaborative work with HP Inc., which bridges a gap between 2D nanomaterials research, ink development, and textile manufacturing, which will enable better performing wearable devices for an ever-growing smart textile industry.

21:35 (New York) /
02:35 (London) / 10:35 (Tokyo)

Closing Remarks, *General Chair Teruaki Mitsuya, Ricoh Company, Ltd (Japan)*