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"THE WINDOW ON IMAGING"

Inkjet Printing of Materials as a Mimic of Biological Growth

Yuka Yoshioka, Ghassan Jabbour, and Paul Calvert

University of Arizona, Arizona, USA

Abstract

Inkjet printing is familiar as a method for printing ink on absorbent paper. In principle the method can be used to print multilayer devices, but we will then need to be able to control the structure of material deposited onto hard surfaces and to overprint different materials on one another. This paper deals addresses the approaches available to form materials by reaction between successive ink layers. The short diffusion distances allow uniform structures to form instead of interfacial barriers or precipitates that would result on a larger scale. Many aspects of these processes can be compared to those that occur during growth of biological tissues. Thus, biology may be a fruitful source of ideas on how to exploit this technology.

Multilayer Manufacturing and Biological Growth

The manufacture of silicon electronic devices depends on a series of steps to add or remove material on a wafer surface in patterns. Inorganic materials are typically deposited by vapor-phase processes and are patterned using photoresists. Most polymers cannot be vapor-deposited and so are spin-coated, patterned by exposure to UV light and the excess washed away. Many of the processes are thus subtractive rather than additive. As each layer is deposited, it must not react or otherwise change during the processing of subsequent layers.

There is much current interest in making multilayers of polymers and small-molecule organic materials for OLEDs (organic light-emitting diodes) and OTFTs (organic thin-film transistors). The available processes are more limited because there is no large chemical contrast between resists and organic active materials. Thus, controlled removal to form patterns is much more difficult. Many groups are developing printing methods to form these devices. The general approach is to use printing to pattern one layer and to deposit the others as uniform layers by spin coating or vapor deposition. Available printing methods include microcontact printing, inkjet printing, silk screen printing and others. Each has its advantages and disadvantages in terms of speed, resolution and range of useable materials. An alternative is to use conventional methods to pattern an inorganic substrate and then deposit all the organic layers as uniform sheets.

Our group has had a long interest in biomimetic materials and processes. Many biological growth processes also depend on the serial deposition of materials with complex structures. The layerwise nature of tree growth is evident as tree-rings. Bones, teeth, shells, tendon, skin and many other materials form by variations of this approach. Often, a layer of cells exports reagents into a thin layer of liquid or gel, which separates the cells from the material being built. There is a parallel with a vapor source delivering material across a vacuum to a substrate on which deposition is occurring. This parallel suggests that it should be possible to form both 3-dimensional device structures and large objects by some sort of repetitive printing process using only mild conditions. There is a

*Presented at the NIP18 Conference, October 2002

concern about growth rates but some biological materials, such as deer antler, form at centimeters/day, which must be comparable with vapor deposition rates.

In order to explore the potential of this approach, we need a method to mimic cells, that is to deliver sequences of reagents to a substrate in a layerwise manner. We chose inkjet printing because the nozzle size is comparable with that of an animal cell (20-50 microns) and the system lends itself readily to many dilute aqueous solutions.

Inkjet Printing of Materials

Efforts to inkjet print materials have been reviewed recently.[1] The process has been studied in some detail in the context of printing ceramic powders to make alumina and zirconia parts. There have also been extensive studies of printing binder into layers of ceramic powder as a freeform fabrication method.[2] Metal lines have been printed via a printed palladium salt followed by metallization using electroless plating methods.[3] Dielectric layers and many organic compounds have also been printed.

For commercial printheads, the main requirements for the ink are that the viscosity be comparable with that of water and that the surface tension be adjusted to limit wetting of the faceplate around the outside of the nozzle. The ink must be in a solvent that does not attack the cartridge, either through dissolution or corrosion. It is common to add a humectant, a water-soluble, high boiling point liquid such as glycerol. This prevents hard drying of the ink in the nozzle. In piezoelectric printheads, where the drive voltage is high, there may be a problem if the ink is electrically conducting. In thermal inkjet heads there is a concern about degradation as the ink is boiled to expel the drop. However, the heating time is only a few microseconds so the major concern may be contamination of the heated surface.

The resolution of inkjet printing is normally in the range of 50-100 microns with a drop size of 25-50 microns. Printing on a hard substrate can be quite different to printing onto absorbent paper but there has been little study of the details of the wetting and drying process. The drop sizes of commercial inkjet printers are decreasing in order to attain higher resolution. In conventional printing there is a constraint that printing times should not increase too much. If a printer were designed specifically for device manufacture, this constraint might be relaxed. Recently it has been shown that prepatterned substrates can be used to make very fine (5 microns) features by differential wetting.[4]

Our studies have mainly been carried out using refilled Hewlett Packard thermal inkjet heads mounted in an x-y-z stage. Pulses are applied to an individual nozzle in order to form single drops under control as the head is moved over the substrate.

Multilayer Inkjet Printing

In building multilayer structures by inkjet printing, there are a number of concerns. One wants to be able to print individual dots, lines and areas. One wants to be able to make thick layers by repetitive printing. One wants to be able to build layers of different materials without them mixing. It may be necessary to wash away reaction by-products at intermediate stages without destroying the device. Since it is desirable to use flexible organic substrates for organic devices, one wants to achieve good adhesion and properties without high temperature steps.

Overprinting of Lines

A dilute suspension of conducting polymer, poly(2,3 dihydrothieno-1,4-dioxin/poly(styrenesulfonate), (PEDOT) was printed onto glass slides as a sequence of dots spaced to form a line. As shown in figure 1, sequential printing over a single line gives a linewidth of about 150 microns that does not change as 30 layers are printed. Individual dots are in the size range of 50-100 microns and the greater width of the lines may be due to fluctuations in droplet placement. About 100nm of material is added for each layer. Conductivities were measured in the range of 1-5 $S.cm^{-1}$, which gives a resistance of about 10 kohm/cm for a line 2 microns thick.

In figure 2, lines are printed side-by-side in order to produce a conducting area. The result is shown for printing the lines with an offset of 50 and 100 microns. In the latter case, we obtain a flat area of conductor about 700 microns wide and 2 microns thick with a thickness variation of ½ micron. AFM studies of these areas suggest that there may be pinholes through the film.

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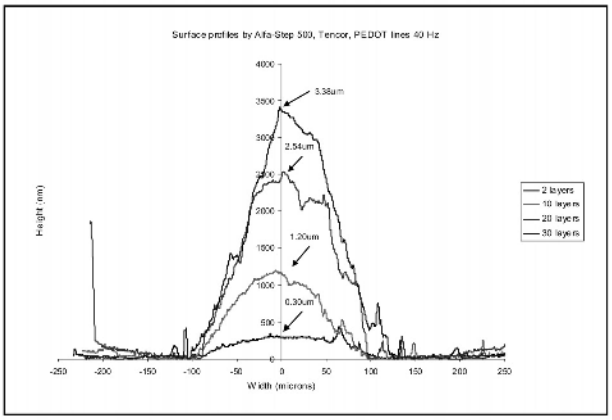

Figure 1. Profiles of inkjet printed PEDOT lines with 2 to 30 layers. Each layer is about 100 nm thick.

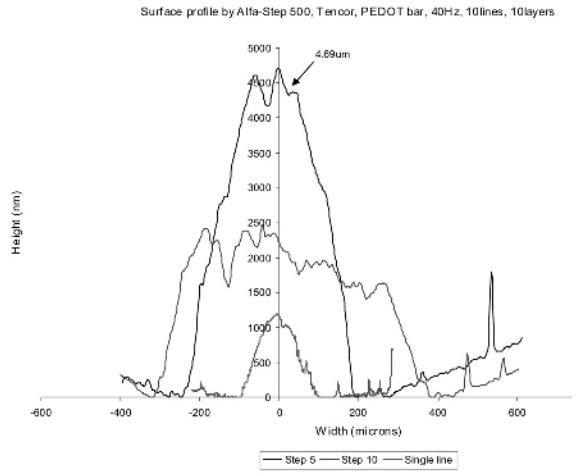

Figure 2. PEDOT lines printed side-by-side to form a layer. 10 lines printed each offset by 12 microns (high peak) or 25 microns (flat profile). Compared with 10 overprinted lines (small peak).

Reaction Between Layers

By inkjet printing it is possible to deposit layers of differing materials on top of one another. By sequentially printing two reactive components it is possible to form an adherent solid film by diffusion and reaction. This film can trap other species. If the solid product is not strongly swollen by water, the film will become a dense substrate for deposition of further materials. In this way, multilayer devices may be built.

By printing multiple layers of a water-soluble epoxide, diglycidylglycerol, and a water soluble amine, triethylenetetramine, we have formed cross-linked epoxies which are water-swellable but not soluble. These layers can be printed onto silicon wafers, which then allow infra-red spectroscopy to monitor the curing reaction of the amine and epoxy. Figure 3 shows that the epoxy peaks in the region of 800-900 cm^{-1} are consumed when the amine is overprinted.

This is a diffusion-and-reaction process, which we have modeled with a simple finite-difference method. As shown in figure 4, two layers each 5 microns thick are allowed to react. The central peak shows the gelled reaction product building up as the epoxy and amine diffuse together. By varying the reaction kinetics or the diffusion rate, the gel may form a uniform layer (fast diffusion) or may form a dense barrier between the two layers (slow diffusion).

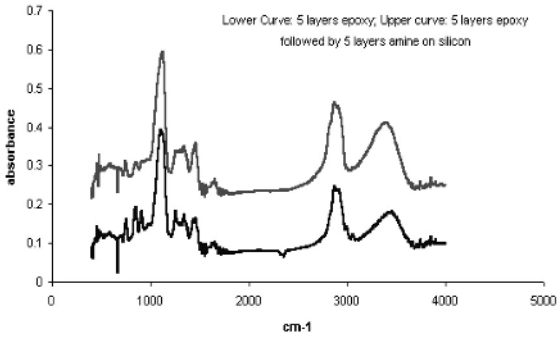

Figure 3. Infrared spectra of 5 printed layers of epoxy solution (lower curve) and after overprinting and reaction 5 layers of amine (upper curve).

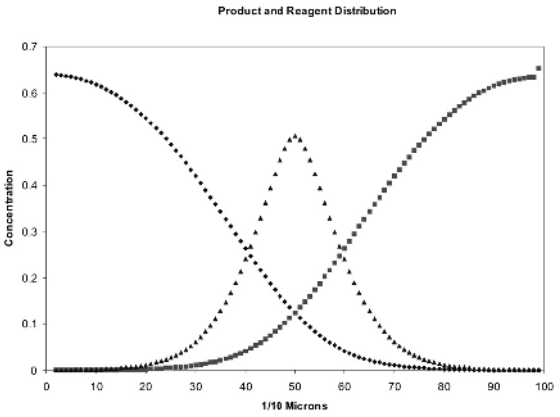

Figure 4. Model for layers of two reagents, each 5 microns thick, that diffuse and reaction to form a product at the interface (central peak).

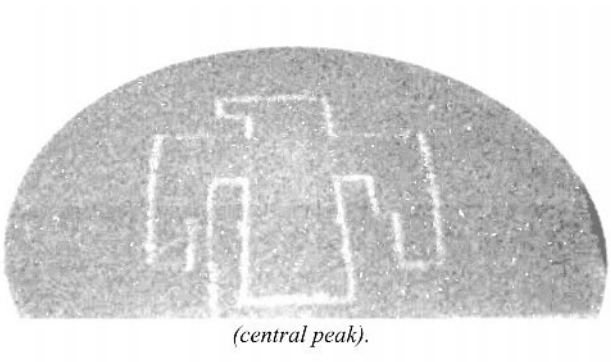

Figure 5. Fluorescent image of labeled bovine serum albumin printed and immobilized in a printed epoxy gel.

In the biological growth processes, mentioned above, the tissue is not formed by two layers of reactants but by reactants emitted from a single layer of cells. In this case it is not immediately obvious how tissue formation can be controlled, except directly at the cell surface. The models show that combinations of fast-diffusing reagents and slow moving inhibitors or catalysts, coupled with timed release, can give rise to layers of products at a distance from the source. In principle the same ideas could be applied to inkjet printed layers in order to form products within or below the topmost layer of material. Thus, it should be possible to form buried layers.

In addition to the epoxy system outlined above, we have printed successive layers of cationic polymer (polydimethyldiallyammonium chloride) and anionic polymer (sodium polystyrenesulfonate). In this case there is no simple spectroscopic method to follow the reaction. As initially deposited the layers can be readily redissolved in water. After annealing in a humid atmosphere at 50°C overnight, the layers become insoluble, presumably because the two polymers diffuse and form an ionic complex.

Immobilization of Polymers and Particles

We have also explored the use of printed gels to provide a matrix in which other materials can be immobilized. We have printed densely packed layers of alumina particles by combining layers of epoxy, of amine and of a suspension of 0.3 micron alumina in water. The gelation of the polymer serves to prevent subsequent redispersion of the alumina. The same system can be used to trap proteins in a printed gel. Figure 5 shows a printed pattern of fluorescent bovine serum albumin immobilized in an epoxy resin matrix.

Conclusions

Inkjet printing has the potential to be a versatile technology for many types of organic devices. As with conventional printing, we can expect different methods to be used depending on the required resolution and the number of parts being made. In the context of our previous work on freeform fabrication, inkjet methods should allow components to be incorporated into parts to give combinations of mechanical and sensing functions more similar to those of animals.

Acknowledgements

We would like to thank Drs Jeffery Brinker and Hong Yu Fan of Sandia National Labs. for their co-operation and the National Textile Research Center for partial support of Ms Yoshioka.

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NIP18 Conference Report

IS&T's NIP18 International Conference on Digital Printing Technologies was held in San Diego, California from September 29 to October 4, 2002. The conference had grown both in size and scope, and attracted a record number of over 860 participants from all around the world.

NIP18 featured over 210 papers were presented in 21 sessions of the three-track Technical Program. The program included the work by authors from five continents and 24 countries.

Monday through Thursday began with Keynote addresses by industry leaders at Royal Phillips Electronics, Sharp Corporation, Xerox Corporation and Clariant GmbH. The topics ranged from digital displays to production digital printing, and to colorants for digital printing.

An Award Talks Session was a new addition at the NIP18 conference. Following the awards ceremony on Tuesday, the winners of the 2002 Honorary Membership, 2001 and 2002 Carlson Awards, and 2002 Kosar Award, presented overviews of their work and their chosen fields.

The Special Topics Program, in its third year, had become a regular feature of the conference, providing coordinated and comprehensive presentations on very timely topics by invited experts. Four Special Topics Sessions were offered at NIP18: *Security Printing and Document Forensics*, *Plastic Electronics: Crossover Technologies, Non-Traditional Applications of Ink Jet Technologies,* and *Digital Printing: Industrial and Commercial Applications.*

The Tutorial Program featured 34 tutorials on diverse topics; some of the new topics included digital watermarking, organic electronics materials, external additives for toners, and image permanence. The Exhibit was the largest ever, with 56 vendors/suppliers showcasing a wide range of products, applications and services.

NIP18 also included other exciting events. A panel discussion on *Forensics, Security Printing and the Printing Industry* was a big success. Lorelei Pagano (United States Secret Service) and Sara Church (Bank of Canada) moderated the discussion. The participants learned a wide variety of criminal usage of digital imaging devices and exchanged ideas about prevention and market incentives. The Textile Forum focused on the substrates and their chemical preparations that improve print quality and enhance fixation. The NIP18 participants were able to examine state-of-the-arts print samples at the Print Gallery and Textile Exhibit.

Eric Hanson, Howard Taub, Yee Ng and Albert Pan at Conference Reception

This year, a meeting of the ANSI/ ISO subcommittee IT9-3 was held concurrently with the NIP18 conference. This subcommittee's mission is standardization of methods for measuring the stability of color pictorial images. This IT9-3 meeting brought many new participants to the NIP18 conference, in particular to the Image Permanence session.

Although the conference was activity-packed, there were some occasions to relax and network. The Sunday evening ice-breaker and Wednesday evening Conference Reception were very well attended. As usual, the ice-breaker was the time to renew old acquaintances and make new friends and business contacts. In accordance with NIP tradition the Conference Reception was on Wednesday evening in a large ballroom, where we were treated to a Mexican feast, complete with a roving mariachi band.

Below are some highlights of the many special events of the conference.

Keynote Addresses

This year's NIP made an effort to glimpse into the future of imaging and look at future developments in printing.

Two keynote addresses, one given by Nils Buijs from Phillips and one by Yutaka Ishi from Sharp covered two aspects of soft or dynamic display, which is expected to impact the way images will be used. The first keynote covered the coming ubiquitous use of thin, inexpensive and/or flexible displays. Buijs described a way to manufacture thin displays by ink-jetting the filter layer and micro-contact printing the pixel address layer. He also discussed new ways to produce flexible displays and very thin LCD panels as well as the first application of polyLEDs in small household appliance displays. The second talk focused on mobile and smaller LCD displays, their wide use in our daily environment where lightweight, low power consumption, high resolution and good visibility in all lighting conditions are a prerequisite. The design for these properties has reached new heights.

Larry Schein with NIP 18 General Chair, Mashiho Yuasa at the Welcome Reception

Dr. and Mrs. Kuniki Seino (left) celebrate Dr. Seino's Senior Member Award with other members of the NIP community from Japan.

Rafik Loutfy of Xerox Innovation Group described the major transitions currently seen in the printing industry. The trend is to go from make and sell to sell and make, from mass production to mass customization, from local business and paper to global business and paper and from mainly mono printing to digital color printing. He described the digital printers that have made these transitions possible, with the third generation today geared for 100 ppm color and 2 million monthly volume. He also discussed a new, controlled growth 'EA' toner technology producing mono-modal, shape-controlled toner particles.

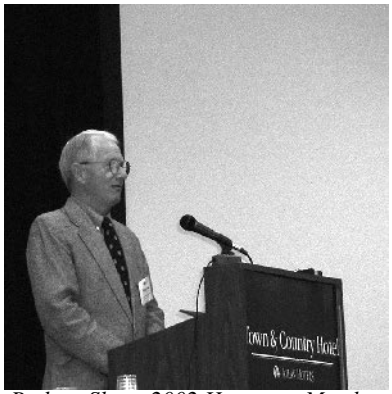
Finally, Hans-Tobias Macholdt of Clariant gave an overview of all there is to know about colorants (pigments and dyes) used in digital imaging. Non-traditional printing applications represent only 1% of the pigment market today, but with very high requirements on several performance attributes. The various pigment classes and their classification were discussed. World-wide and regional ecological and legal requirements pose an additional challenge to the manufacturers in selecting the right pigments. A new manufacturing process in a very small flow reactor, as opposed to the large vessels in the traditional batch process, opens new synthetic possibilities and the potential for customization of pigment production.

Awards Session

For the first time at the NIP a special Awards Talks Session was held directly after the Awards Ceremony on Tuesday morning. There were four talks. First was by Rodney Shaw, Hewlett-Packard Corp., who received an Honorary Membership, the highest award bestowed by the Society. In his brief acceptance remarks Rodney encouraged younger members to become involved with the Society. He indicated that such involvement with the IS&T would return many dividends over the course of their careers and the benefits would far outweigh the work involved. His talk, "A Century of Image Science," was an enlightening review of the subject from a historical perspective, using digitized images of imaging science luminaries to illustrate many of the important concepts.

Tetsuo Murayama, Mitsubishi Chemical Corp., received the Chester Carlson Award in 2001, but he was unable to attend NIP-17. We were indeed fortunate to be able to honor him at NIP-18. His talk, "The Design of High Performance Organic Photoconductors," covered the broad range of organic photoreceptor research, where his contributions have been so important. This included the design of high efficiency charge generation pigments and high mobility charge transport materials. When confronted with the failure of the hotel's computer projection system, Murayama seamlessly presented his talk using transparencies, demonstrating that thorough preparation pays off in presentations as well as in research!

The 2002 Chester Carlson Award was presented to Robert Nash (Consultant, Hafren Associates) and John Bickmore (retired from the Xerox Corp.) Nash, in his award talk, "The Impact of Digital Xerography on Marking Materials," described the substantial efforts required to produce dry toner for analog electrophotography and the new requirements necessary for the transition to digital. Major changes are the reduction in toner size, change in toner polarity and the change from grinding to chemically-produced toner which is monodispersed with controllable size and morphology. Thus, there are many exciting new challenges for the scientists and engineers preparing marking materials for tomorrow's digital electrophotographic printers.



Rodney Shaw, 2002 Honorary Member at the presentation ceremony.

The final talk of the morning was by Ikuo Hibino (Alps Electric Co.), who received the Kosar Award. In his talk, "Study of High Definition Thermal Transfer Ink Ribbon," he described the details behind the design of a 600 dpi high-definition thermal printing process. Thorough theoretical analysis and experimental testing of the forces involved in transferring ink from a multi-layered ribbon to the receiver were used to predict and perfect the desired materials characteristics. The ink ribbon substrate was polyester (2.5 micron). A wax-based 0.9 micron release layer was placed between the base and a 1.3 micron ink layer (ethylene vinyl acetate copolymer-based). A silicone lubricating layer of 0.25 micron was formed on the reverse side of the base film to complete the package.

Special Topic Sessions

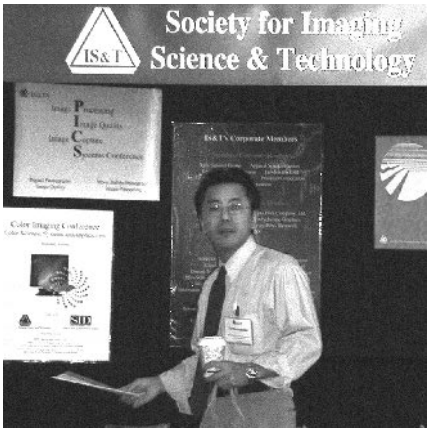
Four very well attended "Special Topics" sessions this year successfully continued the three-year old institution of invited sessions. These sessions focused on new developments or emerging fields related to the NIP technologies and aimed to present an authoritative overview for the broad NIP audience. All of the topics this year lent themselves to "topic theme days" through coordinated scheduling with associated keynotes, regular sessions, or panel discussions.

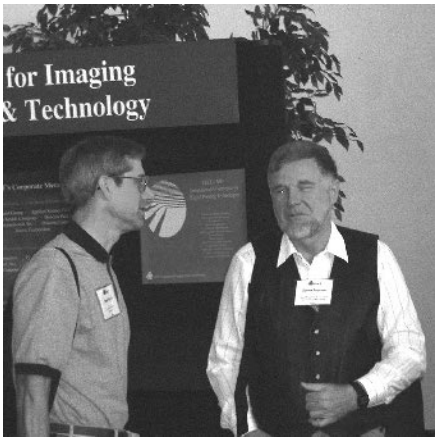
Plastic Electronic: Cross-over applications

The Special Topics Session on Plastic Electronics provided an important forum for discussing a new technology squarely rooted at the intersection of two fundamental NIP disciplines. The ability to "print"

organic and inorganic electrical devices and circuits has been enabled by advances in both organic photoreceptor engineering and in the development of material-tolerant ink jet printing methods and ejection devices. Topics ranging from the printing of organic light emitting diodes (OLEDs) and organic thin film transistors (OTFTs) to plastic based displays and photovoltaic devices were presented.

The session began with an overview of recent work at Lucent Technologies by John Rogers. Specifically, materials and patterning techniques focused on the development of plastic active matrix back-plane circuits for flexible, paper-like displays were presented. A unique approach using a "stamping" process was outlined. By transferring patterns of molecular "inks" from a high-resolution rubber stamp, features consisting of self-assembled molecular films are deposited. These features are then used in subsequent processing, patterning and device fabrication. Devices fabricated using this novel lithographic process show promising performance.





Ghassan Jabbour provided an overview of device printing work that is underway at the University of Arizona. Work in this laboratory has focused on new methods to print electroluminescent devices, plastic-based solar cells, and high performance OLEDs and OTFTs. During this presentation, Jabbour discussed recent results in device fabrication leveraging both screen-printing and ink jet printing approaches. Of particular note was the discussion on ink jet patterning using thermal ink jet print heads. While most work in this area relies on the use of costly piezoelectric print heads to deposit sensitive organic materials, the Arizona work has shown that these electronic materials can be engineered to be ejected using low cost thermal ink jet print heads without compromising the device performance.

Recent work at DuPont Displays on the fabrication and manufacture of monochrome and full-color displays using ink jet printing was presented by Matthew Stainer. Stainer outlined the remarkable progress that DuPont Displays (Uniax) has made in transforming ink jet printing into a reliable manufacturing process. By focusing on the formulation and engineering of "jettable" electrically active polymer "inks" and by optimizing substrate properties, DuPont is making important progress towards large scale manufacturing and commercialization of polymer-based full color displays. At the end of the presentation, Stainer outlined the key technical issues and problems which still remain in the development and practical implementation of ink jet processing.

The last speaker in this session was Tom Jackson from Pennsylvania State University. He provided a broader view of plastic-based, "ubiquitous electronics" in a talk entitled: *Thin Film Electronics–Electronics Everywhere*. While the work at Penn State has focused on new methods of processing organic materials, this work has also included substantial effort on the development of low temperature processing of inorganic materials. New, low temperature processing methods can be used on a wide variety of flexible, transparent substrates and expand the options for low cost consumer electronic products. Furthermore, by developing processing and fabrication methods which permit the integration of amorphous silicon (a-Si:H) devices with organic materials such as pentacene, it becomes possible to build low power complementary circuits. This last presentation captured the overall vision and promise that new plastic-based printing and processing methods bring to a rapidly emerging market.

Security Printing

Advances in digital imaging technologies have made communication and printing a simple task for everyone. On the other hand, protection and authentication of printed media has become more difficult because of the same technologies. The consequences of all these advances have become important to government, business and the general population. This session provided the first forum where the security printing industry and imaging scientists and engineers could discuss the problems that have arisen due to the improvements in digital imaging. These include the steps taken to track the printed documents to the printer that produced it, the protection of the content of a document using digital methods, and the design of documents to prevent illegal reproduction.

Marc Gadreau of Canada Customs and Revenue Agency talked about "Forensic Science and the Digital Printing Industry". He explained the procedures and features that are used in forensic science to link documents and individual printers. He explained the use of print quality metrics and chemical analyses to aid in the forensic effort and asked for help from the printer engineering community in delineating more features that can be used for this purpose. John Haslop of De La Rue Currency presented the problems that currency community has with the increase of digital methods for counterfeiting. The new term "digifeiting" (originally coined by Sara Church) is being used to describe the problem. He surveyed the defenses that the currency printing community has taken in both the use of visible features to provide authentication of a banknote, as well as hidden features that can be used for machine recognition. Ed Delp of Purdue University spoke about using digital watermarking to protect the content of a document.

The afternoon started with a talk by Thomas Jagielinski of San Diego Magnetics that covered Forensic Document Examination Using Magnetic Imaging Techniques. This invisible deterrent can be used to authenticate high value documents. Tony Harris of Software 2000 presented the role of the print driver in security of printing and emphasized that security must be a layered approach.

Automated image analysis techniques were discussed by David Wolin of ImageXpert. He described the machine-vision image quality analysis that can be used in document verification. The application of these techniques was explored by John Oliver of the Alberta Research Council. Using the ImageXpert print quality analyzer, unique print signatures of seven different printers could be identified. When combined with analysis of the paper and ink chemistry, this becomes a powerful detection procedure.

The panel on Security Printing, moderated by Sara Church and Lorelei Pagano included John Haslop, DeLa rue Currency; Jan Laethem, Dotrix; Helmut Kippan, Heidelberg; and Donna Eisenberg, United States Immigration and Naturalization Service. Notable was the strong audience presence and interaction with the panel.

Non-Traditional Ink Jet Applications

"Inkjet Printing of Materials as a Mimic of Biological Growth," presented by Paul Calvert, University of Arizona, considered the possibility of jetting a variety of fluids in layers that simulate biological structures. The dimensions of such structures are similar to those occurring in nature, and chemical reactions in successive ink layers can be compared to those that occur during growth of biological tissues. As Calvert stated, this was the only paper at the conference that featured SEMs of bones.

"Digital Ink-jet-based Printing: Beyond Color," was contributed by Superior MicroPowders, Albuquerque, New Mexico. Toivo Kodas discussed opportunities for reducing manufacturing costs for OLEDs, fuel cells, thin-form batteries and smart cards by additive processes that rely on ink jetting novel fluids. These unique fluids typically have very expensive ingredients and require deposition of a controlled amount of liquid in a precise location. Ink jet technology is particularly suited to this process.

David B. Wallace presented "Solder Jet ™ - Optic Jet ™ -AromaJet ™ - Reagent Jet™ - Tooth Jet ™ and other Applications of Ink Jet Printing Technology." The title of this paper is very descriptive of the applications for MicroFabTechnologies' single nozzle jet. The ink jet works with fluids ranging from room temperature to 370 °C making it useful in applications such as genetic diagnostics, protein based drug discovery, light emitting polymers and solders.

Discussion with Ikuo Hibino after his awards presentation.

Digital Printing, Commercial and Industrial Applications

The session provided an update of the status of this field with morning presentations by C. Bondy from NexPress, on "Digital Color Printing: Expanding Solutions and Applications" and N.R. Schwartz from Flint Ink, on "Ink Jet Printing in Industrial and Commercial Applications". The afternoon comprised "Revolutionary Xerographic Digital Production Press" by P. Garsin of Xerox, "The Fundamentals of HP-Indigo's Digital Offset Color Printing and How it Rivals Mechanical Offset Printing" from the HP/Indigo Division and "Printing for an Audience of One", by R. J. Barbera of Xeikon.

Finally, the Image Permanence Session was held adjoined with the ANSI/ISO subcommittee IT9-3 meeting about Methods for Measuring the Stability of Color Pictorial Images. Henry Wilhelm, who is the secretary of IT9-3, chaired the session, which touched on all the major topics that IT9-3 is currently trying to incorporate in the upcoming standard.

Various hardcopy technologies were compared in their stability towards environmental influences, namely temperature, light, humidity and air pollutant attack. No system performs the best for all criteria, with ink-jet dye on porous systems being most sensitive to ozone, ink-jet dye ink on polymer media most sensitive to humidity and electrophotography up to now lacking the image quality. Pigment inks on porous media seem to be the best compromise for stability on porous receivers but suffer from color gloss and differential on glossy prints. The various aspects of ozone degradation of prints were elucidated by several speakers. Another long-standing topic was the relationship between accelerated standardized ageing tests and actual real-life fading needed to predict life expectancies.

Thank you to the NIP18 Exhibitors whose presence added so much to a great conference!

Dominion Colour Corporation

Esprix Technologies

Sensient Technologies Corporation

7-SIGMA, Inc.
Accu-Automation Corp.
American Ink Jet Corporation
Arizona Chemical Company
Avecia InkJet Printing Materials
BMP America
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Clariant Corporation
Degussa Corporation
Dominion Colour Corporation
Elementis Pigments
Epping GmbH-PES Laboratorium
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Kendro Laboratory Products
Kyocera Industrial Ceramics Corp.
LogLight Designs
Lyondell Chemical Company
M. Theiss Hard and Software
Netzsch Inc.
Orient Chemical Industries, Inc.
Pall Corporation
Pivotal Resources, Ltd.
Powdertech International Corp.
Q-Panel Lab Products
Quality Engineering Associates (QEA), Inc.
Sartomer Company, Inc.
Schlegel Systems, Inc.
Sensient Technologies Corporation
Spectra, Inc.
SunJet Coates Screen,
The Technology Partnership PLC
Tex Tech Industries
The Tiara Group, LLC
Toner Research Services
Torrey Pines Research
TREK, Inc.
Triangle Digital
Wacker-Chemie GmbH
Winfield Industries, Inc.
XAAR, PLC
Xennia Technology, Ltd.


Elementis Pigments

Hodogaya Chemical

SunJet Coates Screen

STANDARDS

Standards Update

David Q. McDowell, Editor

This issue of Standards Update reviews the activities at the recent meetings of ISO TC130, Graphic technology, and ISO TC 42, Photography.

TC130, Graphic technology

ISO TC130 held a series of working group meetings and a Plenary meeting in Berlin the week of September 23, 2002.

For those not familiar with ISO jargon, a Plenary meeting is a meeting of the national body representatives of an ISO Technical Committee held to either take action on behalf of the Technical Committee or to review and approve actions (resolutions) requested by working groups within the Technical Committee. Plenary meetings are typically only held once a year or once every two years.

Some of the events or actions of general interest arising from the TC130 meetings, grouped by the applicable working group, are:

WG1, Terminology. Not unexpectedly, this working group has struggled more than most in finding both active participants and leadership. Within TC130, since its inception, the responsibility for chair and vice-chair of individual working groups has been assigned to national bodies. In the meeting in Berlin responsibility for the WG1 chair was transferred from Germany to the UK and for vice-chair from the US to Brazil.

WG1 is about ready to issue a draft for DIS ballot of 12637-1, *Graphic technology — Multilingual terminology — Part 1: Fundamental terms.* This will be the second standard issued in the TC130 series of terminology standards and will joining the already published ISO 12637-5:2001, *Graphic technology — Multilingual terminology of printing arts — Part 5: Screen printing terms.*

WG2, Prepress Data Exchange, identified three areas of new work that represent exciting opportunities.

- The recently approved ANSI/CGATS.20:2002, *Graphic technology - Variable printing data exchange using PPML and PDF (PPML/VDX)*, has been offered to TC130 for consideration as an International Standard. TC130 has agreed to initiate a new work item for this work.
- Ongoing discussions with the ICC and the ISO management have led to the possibility of a formal working relationship which will allow the ICC the control over and involvement with the ICC specifications that they desire while still enabling joint development of the ICC Profile Specification as an International Standard. TC130 has aggreed to participate in its preparation and the proposed agreement is currently being reviewed within the ICC. TC130 has also agreed to create a joint working group (JWG), to involve other ISO TCs in this work, once ICC concurrence is received.
- Work has ben initiated under the leadership of have been initiated between AIIM (the Secretariat of ISO TC171 SC2) and NPES concerning the potential development of an International Standard, based on the Adobe PDF file format, to electronically archive documents to ensure preservation of content for an extended time period. This activity is presently identified as PDF/A. (See www.aiim.org/pdf_a) Both AIIM and NPES are recommending that this work be conducted in a JWG under the leadership of TC171/SC2. TC130 indicated its willingness to participate in a JWG in this area. TC171/SC2 is beng asked to initiate the neccessary ballots to create a new work item and a JWG in this area.

In addition WG2 reported that several standards had been forwarded to ISO central secretariat for balloting. These included:

- ISO 12639, G*raphic technology — Prepress digital data exchange — Tag image file format for image technology (TIFF/IT)* submitted for DIS ballot. This is a revision of the 1998 version which has been updated to include new capabilities, as well as a new constrained conformity level called Profile 2 (P2) to supplement the previously defined Profile 1 (P1), which is unchanged. The key added capabilities include: a normative final page (FP) format; a new SD file format with optional G4 compression for copy-dot data; definitive ways to use RGB and CIELAB color spaces in CT, as well as 16-bit-per-channel data in CT; JPEG compression in CT and MP; Flate compression in all formats except LW, HC and BL; spot colors (colors other than cyan, magenta, yellow and black) in LW, CT, HC, MP, BP, BL, and SD; and support for up to 65535 colors in LW colour palettes.
- *ISO 12640-2, Graphic technology — Prepress digital data exchange — Standard colour image data — Part 2: XYZ/sRGB encoded image data (XYZ/SCID)*, submitted for DIS ballot. This complements the current CMYK/SCID image set and provides a set of standard images that are restricted to the sRGB gamut. Image data is provided in both 16-bit CIEXYZ data and 8-bit sRGB data.
- At the request of WG2, TC130 agreed that three standards in the PDF/X family should go directly to DIS ballot. These are revision to ISO 15930-1:2001, *Graphic technology — Prepress digital data exchange — Use of PDF - Part 1: Complete exchange using CMYK data*, and ISO 15930-3:2002, *Graphic technology — Prepress digital data exchange — Use of PDF — Part 3: Complete exchange suitable for colour managed workflows*, to add compatibility with Adobe PDF 1.4. In addition ISO 15930-2, *Graphic technology — Prepress digital data exchange — Use of PDF — Part 2: Guidelines for partial exchange of printing data (PDF/X-2)*, has been completed and is ready for its first DIS ballot.

WG2 also reported that ISO/TR 16066, *Graphic technology — Standard object colour spectra database for colour reproduction evaluation (SOCS)*, has been approved and the final draft of this technical report has been sent to ISO Central Secretariat for publication.

WG3, Prepress Process Control reported that ISO15790, *Graphic technology and photography — Reflection and transmission metrology — Certified reference materials - Documentation and procedures for use, including determination of combined standard uncertainty*, has been approved and is in final preparation for publication.

Revisions of ISO 12647-1:1996, *Graphic technology — Process con-*

trol for the manufacture of half-tone colour separations, proof and production prints — Part 1: Parameters and measurement methods, and *Part 2: Offset lithographic processes* have been started and are in CD ballot.

WG3 also recommended that ISO 12647-3:1998, *Graphic technology — Process control for the manufacture of half-tone colour separations, proofs and production prints — Part 3: Coldset offset lithography and letterpress on newsprin*t, be revised to bring it into better compliance with current practice. It was suggested that the sub-title be change to be simply *Part 3: Coldset offset lithography on newsprint*. Proposed changes include a revision of the definition of the magenta ink colorimetric aim, definition of the colorimetry of the three-colour overprint, a higher dot gain curve, and the new higher brightness newsprint. It is hoped that as part of this revision even better agreement can be achieved between the United States, European, and Japanese newspaper printing standards.

WG4, Media and Materials, continues its work on several standards involving materials used in graphic technology. Most significant of these are the work to develop ISO 15994, *Graphic Technology – Testing of prints – Determination of visual lustre*, and ISO 20101, *Graphic technology — Process control — Cell volume measurement: Measurement and interpretation of anilox cells*.

WG5, Ergonomics - Safety, also met during this period. While their work is critical to the printing and publishing community, it is not generally of interest to the imaging community and is therefore not reported here.

TC42, Photography

TC42/JWG 20, JWG21, JWG22, JWG23 , and WG18 all met in Berlin during the period September 30 through October 10. That scheduling was deliberate because all four JWGs involve participation by TC130.

JWG21, Revision of the ISO 5 series of densitometry standards, is responsible for the revision of all parts of the ISO 5 family. The new title of ISO 5 is *Photography and graphic technology — Density measurements* which recognizes the broader applicability of these standards. The names of the various parts, which are unchanged, are: *Part 1: Terms, symbols and notations, Part 2: Geometric conditions for transmission density, Part 3: Spectral conditions*, and *Part 4: Geometric conditions for reflection density.*

The goal of this current revision is threefold. First, all of the documents fail to adequately differentiate between the definition of density and the practical requirements for, and tolerances on, the measurement of density. Second, these standards have not kept up with the needs of graphic technology applications. Third, Part 3 is based on the use of filter instruments and makes no provision for the computation of density from measurements of spectral reflectance or transmittance factors. The initial focus has been on Parts 3 and 4 which require the greatest degree of updating. Both have completed an initial CD ballot and the meeting of JWG 21 focused on resolving the ballot comments and determining a way forward.

While the basis of the definition of status density in ISO 5-3 is still the traditional spectral products, these have been extrapolated to provide reference data at 1 nm. These 1 nm data are also defined to be spectral weighting factors for computation from spectral reflectance or transmittance factor data. Because few instruments are available to provide data at a data interval of 1 nm, spectral weighting factors have been included in the standard, for data intervals of 10 nm and 20 nm.

All data will be made available as electronic files and it is expected that this new version of ISO 5-3 will be an "electronic" standard available on CD-ROM or as a downloadable file.

The major change in ISO 5-4 is the inclusion of a normative definition of the requirements for polarization in reflection density measurements. The use of polarization is optional, but when used it must comply with these newly defined requirements. It is recognized that polarization is primarily used in the graphics industry, and even there it is only predominant in some geographic areas.

JWG20, Colour characterization of digital still cameras, is responsible for developing ISO 17321, *Graphic technology and photography — Colour characterisation of digital still cameras (DSCs)*. This is a 2-part standard where Part 1 is subtitled *Stimuli, metrology, and test procedures* and Part 2 is *Methods for determining transforms from raw DSC to scene-referred image data*. It includes procedures for collecting characterization data through use of a reflection or transmission target or by narrow band spectral illumination. Part 1 will have another round of WD comments and is scheduled to be in CD ballot by January 2003. Part 2 still requires some experimental work to determine the preferred path forward. It is not expected to be in CD ballot until late 2003.

JWG22, ISO coordination group for ISO-IEC joint activities re color management, currently is only involved in coordinating ISO input on two standards, Amendment 1 to IEC 61966-2-1, *Multimedia systems and equipment – Colour measurement and management – Part 2-1: Colour management – Default RGB colour space – sRGB* and IEC 61966-2-2, *Multimedia systems and equipment – Colour measurement and management – Part 2-2: Colour management – Extended RGB colour space – scRGB*. The balloting at the DIS stage for both documents resulted in approval in IEC and disapproval in ISO. In follow-up meetings the technical conflicts were resolved, but procedural issues around dual balloting had to be resolved before final balloting of these documents, and their approval as ISO/IEC dual logo standards, could occur.

JWG 23,Extended colour encodings, is charged with the development of ISO 22028 *Photography and graphic technology — Extended colour encodings for digital image storage, manipulation and interchange*. This is intended to be a multi part standards where Part 1is subtitled *Architecture and requirements*. Part 1, which has just entered DIS balloting, describes a reference image-state-based digital imaging architecture and introduces the concept of scene space and rendered space. Subsequent parts will define at least one scene-referred extended-gamut colour encoding and at least one output-referred extended-gamut colour encoding.

WG18, Electronic still picture imaging, is involved in the development of a number of standards.

In the area of scanners, ISO 16067-1, *Photography - Electronic scanners for photographic images – Spatial resolution measurements – Part 1: Scanners for reflective media*, is at the FDIS stage and will soon be com-

pleted. Work is well underway on *Part 2: Film scanners* which is currently in CD ballot. In addition ISO 21550, *Photography - Electronic scanners for photographic images - Dynamic range measurements*, is also in CD ballot.

WG18 is also developing a multipart standard to help define methods of estimating image quality, ISO 20462, *Photography - Psychophysical experimental method to estimate image quality* and includes *Part 1: Overview of psychophysical elements, Part 2: Triplet comparison method,* and *Part 3: Quality ruler method*. All three parts are expected to be available for CD ballot before the end of this year.

It was reported that ISO 12231, *Photography — Electronic still picture imaging — Terminology*, is about to enter its second DIS ballot and that ISO 15739, *Photography - Electronic still picture imaging - Noise measurements*, had been approved and final text is in preparation for publication.

A proposed new item of work called "Picture Archive Initiative" was presented and WG18 agreed to request a new work item for this topic under a slightly revised title of "Picture Storage and Electronic Album". It was suggested that the scope of work in this area could be divided into five categories (a) file system organization, (b) file access rules (c) advanced file access (d) formats for longevity (e) security, privacy, intellectual property of images in archive.

For suggestions for future updates, or standards questions in general, please contact the author at mcdowell@npes.org or mcdowell @kodak.com

2002-2003 IS&T Visiting Lecturer Reiner Eschbach

Reiner Eschbach, 2002-2003 Visiting Lecturer, has chosen as his topic, *Image Reproduction: an Oxymoron.*

Reiner Eschbach received his M.S. and Ph.D. in physics from the University of Essen, Germany, in 1983 and 1986 respectively. He is a Xerox Reseach Fellow and Fellow of the Society for Imaging Science & Technology (IS&T).

From 1986 to 1988 he was a Visiting Scholar at the University of California, San Diego. He joined Xerox in 1988 where he became a Pricipal Scientist at the Xerox Digital Imaging Technology Center in 1994 and a Research Fellow in 2000. He is currently a Project Leader in the Color and Digital Imaging Systems Lab.

His research interests include color image processing, digital halftoning and compression. He is the former Editor of the Recent Progress Series of the IS&T as well as past Secretary and Publications Vice President of the IS&T Board of Directors.

Eschbach currently has more than fifty US Patents in the areas of Automatic Image Enhancement Compression Halftoning Resolution Enhancement Technology Scanning Systems

His publications list includes fifty conference publications and over twenty publications in peer-reviewed journals including:

- Journal of Electronic Imaging
- IEEE Trans. On Image Processing
- Computer Vision, Graphics and Image Processing
- Optics Communication

New Products

Edited by William M. Aitken

DIGITAL CAMERAS

New 22 Megapixel Sensor offers 645 Compatibility

Sinar announced the next step in the evolution of high-resolution professional digital photography. The Kodak KAF-22000CE full frame CCD, tailored specifically to Sinar requirements, features 4080x5440 pixels, each with an edge length of 9 microns. The 4:3 aspect ratio rectangular sensor is 38.8 x 50.0 mm making it suitable as a digital replacement for film in modern 645 medium format camera systems.

Digital Classic Camera

MINOX showed their digital version of the classic Leica M3 at Photokina 2002. Their miniaturized version of this classic camera of the fifties features a 1.3 Megapixel sensor and both still and video capture modes. The DCC Leica M3 has 32 MB of internal flash memory, sufficient to store 60 images in high-resolution mode. Image data can be downloaded to a PC via USB cable.

Additional information is available from Minox GmbH Optische & Feinmechanische Werke, Andrea Schmidt – Agel, Walter – Zapp – Strasse 4 . D-35578 Wetzlar; Phone +49 (0) 64 41-917-613; Fax +49 (0) 64 41-917-612; email: info @minox.com; Internet: http:// www.minox.com

Camera Outfit Promotion

Hasselblad is offering a consumer rebate promotion on the 501CM and 503CW cameras effective through December 31, 2002. The rebates provide Hasselblad accessories valued at up to $1,119. These cameras are compatible with a full range of film and digital backs. Digital backs from Phase One, Imacon, Sinar Bron, Leaf, Megavision and JenOptik will provide direct digital image capture. The new Kodak DCS Pro Back Plus provides an un-tethered high quality digital solution for location photographers. Alternatively, new medium format film scanners from Imacon, Polaroid, Minolta and Nikon provide extremely high image quality at very attractive price points.

For more information contact Richard Schleuning, VP Marketing at 973-227-7320 x228 or via email at rschleuning@hasselbladusa.com

New Camera has 35MM Sized 13Mpixel Sensor

The Kodak Professional DCS Pro 14n Digital Camera features the industry's first 35mm size CMOS sensor in an SLR Camera model. The new sensor boasts 13.89 million pixels and provides variable resolution raw files. The camera, built on a Nikon lens mount, adds speed to the photographer's workflow through FireWire connectivity at a 12 MB per second. Estimated street price will be around $4000.

For information: 800-235-6325 or the Kodak Professional web site at www.kodak.com/go/professional

16Mp Digital Back in 645 Format

The new Kodak DCS Pro Back 645H digital camera back, compatible with the new Hasselblad H1 System, features 16 Mega Pixel resolution, an on-board power source, full featured LCD display and all attributes of the earlier 645 format camera backs. Suggested US list price is $11,995. For information, see above references to Kodak Professional.

Machine Vision Camera with 1/ 96000 sec Shutter Speed

Panasonic Vision Systems GP-MF622 camera features a ½ inch interline transfer CCD that produces 570 lines of resolution with a minimum illumination of only 1 lux and S/N of 56db. The cameras 11 electronic shutter speeds range from1/60 to 1/96,000 seconds and can be triggered from an external source. The unit weighs 86 grams and offers shock resistance to 80G and vibration resistance to 10G. Manufacturers suggested list price is $545. For information, email: vsg@panasonic.com

Web: www.Panasonic.com/ visionsystems Toll free telephone: 888-880-8474

NEW PRODUCTS

MEMORY CARDS

Unit Images Memory Cards Direct to TV

Delkin's eFilm Picturevision is a small set top box that accepts digital camera memory cards and displays the images on TV. Connection to the TV is with an included AV cable and requires no computer or software. The unit accepts every digital memory card format currently on the market and needs no adapters. The included remote control enables slide show viewing of images, custom settings for the display and zoom and rotate functions. The Picturevision also plays MP3 audio files either through the TV or connected directly to a stereo system. It will also play back VCD and MPEG (I&II) video files. The unit is compatible with both NTSC and PAL video standards for worldwide operation. MSRP is $159.95 (US). For information: media images at: www.delkin.com/media images/.

NEW FILMS AND PAPER

Kodak introduced Ektachrome E100G and 100GX films, a new generation of transparency films with extremely fine grain, lowered D-min for brighter whites and an improved tone scale. The new films utilize Kodak's color amplifying technology and T-Grain emulsion technology.

Kodak also introduced an innovative family of Endura photographic papers and display materials that achieve a new industry standard for image stability and robust processing compatibility in either optical or digital devices.

Information: Kodak Professional; Tel 1-800-235-6325; website: www.kodak.com/go/professional

PRINTING, PRINTERS AND PRINTING WORKSTATIONS

Durst Dice America, LLC (DDA) has officially opened its Durst Rho 160 UV flatbed inkjet printer demonstration center at the company's Rochester NY headquarters. With the UV curable inks used in the Durst Rho 160, visitors can image their own test files directly onto a variety of substrates – up to 62 inches wide, 1.58 inches thick – without the need of expensive dye receptive coatings. Highest quality imaging is at nearly 500 square feet per hour while in standard mode, imaging can achieve 1,000 square feet per hour. Foe more information: Mark Bosworth, Director of Sales, Tel: 585-486-0340 ext 5225, Fax: 585-486-0350, email: markb@durstdice.com.

Laser Printer for Professional Lab Applications

The Kodak Professional RR30 Laser Printer delivers up to 1,178 8x10 inch prints per hour with laser sharp 400 dpi resolution on 350-meter rolls of paper. Designed to Kodak Professional specifications by Agfa, the printer can handle highest volume output requirements while providing outstanding image quality and seamless integration into existing lab digital workflows. MSRP is $180,000. For information: Telephone: 800-235-6325, website: www.kodak.com/go/professional

New Digital Analyzer Workstation for Professional Lab Applications

The Kodak Digital Analyzer Workstation is designed to mimic a lab's traditional analyzer color grading system, such as the Professional Video Analyzing Computer or the Computerized Video Imaging System. The new workstation accepts files from high-resolution scanners and digital cameras. By standardizing digital image files at the start of the workflow, the Digital Analyzer delivers high first time yields from film scanning, delivering high quality and timesavings at every step in the digital workflow. MSRP is $29,950. Information is available at the Kodak Professional website: www.kodak.com/go/professional

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Other Meetings

December 4 - 6, 2002
IDW'02: The Ninth International Display Workshops, Hiroshima, Japan; *Sponsored by:* Institute of Image Information and Television Engineers and The Society for Information Display. For infomation: www.the-convention.co.jp/IDW/

February 18-21, 2003
IDMC 2003, **The International Display Manufacturing Conference**, Taipei, Taiwan. Sponsored by Society for Information Display. For more information: http://www.sid.org

March 2-5, 2003
PMA 2003, Las Vegas, NV. Sponsored by Photo Marketing Association. For more information: www.infopma. 2003.pmai.org

April 6-9, 2003
TAGA 2003, Montreal, Quebec, Canada. Sponsored by Technical Association of the Graphic Arts. For information: http//www.taga.org.

July 8-11, 2002
VCIP 2003, **Visual Communications and Image Processing,** Lugano, Switzerland. Sponsored by SPIE/IS&T. For more information: www.spie.org

Short Courses

RIT (Rochester Institute of Technology) offers an ongoing series of courses on graphic arts and imaging topics. Contact: Ken Posman, 585-475-7429; E-mail: krptpd@rit.edu; www.training.rit.edu.

Upcoming IS&T Conferences

November 12 - 15, 2002
10th Color Imaging Conference - Color Science, Systems and Applications
The SunBurst Resort, Scottsdale, Arizona
Co-sponsored by the Society for Information Display
General Co-chairs: Paul Hubel (IS&T) and Inegborg Tastl (SID)
Program Co-chairs: Brian Funt (IS&T) and Gabriel Marcu (SID)

January 20 - 24, 2003
IS&T/SPIE Electronic Imaging: Science and Technology
Santa Clara Convention Center, Santa Clara, California
General Co-chairs: John Meyer (IS&T) and Robert Sprague (SPIE)

May 13 - 16, 2003
PICS - The Digital Photography Conference
The Hyatt Regency Hotel, Rochester, New York
General Chair: Mark Fairchild

May 18 - 21, 2003
DPP2003 - The International Conference on Digital Production Printing and Industrial Applications
Hilton Barcelona Hotel, Barcelona, Spain
General Chair: Ignacio Fonts

September 28 - October 3, 2003
NIP19: The 19th International Conference on Digital Printing Technologies
Hyatt Regency Hotel, New Orleans, Louisiana
General Chair: Yee Ng

For a more complete listing of imaging conferences, visit IS&T's web site: www.imaging.org

IS&T
The Society for Imaging Science and Technology
7003 Kilworth Lane
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