

DISPLAY WEEK 2018

# Final Call for Papers

SID International Symposium,  
Seminar & Exhibition  
May 20–25, 2018



## Special Topics

- **Augmented Reality, Virtual Reality, and Artificial Intelligence**
  - **Quantum Dots and Micro-LEDs**
- **Wearable Displays, Sensors, and Devices**

Los Angeles Convention Center  
Los Angeles, California, USA

[www.displayweek.org](http://www.displayweek.org)

## Abstract/Summary Format and Submission Requirements

Submissions must consist of two separate parts. The first part is a 35–50 word abstract. The second part is a 4-page technical summary. Please follow the following instructions for the preparation and submission of the abstract and technical summary.

**Page Headers:** Please place the first author's name and the title of the paper on the top of each page of the submission.

**Abstract:** Your submitted 35-50 word abstract, highlighting the key details of your paper, will be published in the Program if your paper is accepted. The abstracts are usually edited to accommodate the program format.

**Keywords:** Include a minimum of three keywords directly below the abstract.

**Technical Summary:** The summary must not exceed four pages in length. Material beyond four pages will not be considered in the evaluation of the paper.

(1) Include the names of all authors with their affiliations, addresses, telephone numbers, and e-mail addresses. Please underline the name of the presenter when there are two or more authors.

(2) Also Indicate whether the presenter is a student.

(3) **Objective and Background:** Briefly describe the goals and intent of your project and give background factors that led to the new results.

(4) **Results:** Describe the specific results that will be presented at the 2018 Display Week Symposium. Please provide a technical description of how the results were achieved. Sufficient detail (quantitative and/or graphical data) should be included so the Program Committee can properly evaluate your submission.

(5) **Impact:** Discuss the significance of your work and compare your findings with previously published work.

(6) **References:** List a few main references covering projects in related areas.

(7) **Prior Publications:** Generally, Symposium papers must be original contributions. If your organization has published or presented material on similar work in English, please explain how the present material differs. The only exception to this rule is that papers submitted to the Emerging Applications Subcommittee need not be original.

**All authors are required to upload their Abstract and Technical Summary to [www.scomminc.com/pcm/sid/sid.cfm](http://www.scomminc.com/pcm/sid/sid.cfm)**

Additional information must be provided on the online submission form. Authors must:

(A) Indicate the full title of the paper;

(B) Provide the name and e-mail of the contact author.

(C) List all the authors and include their contact information,

(D) Insert the abstract and keywords in the allotted space provided;

(E) Check the appropriate box for student travel grants;

(F) Indicate whether your paper is invited;

(G) Indicate if you wish to have your paper considered for oral or poster presentation,

(H) Indicate the closest matching symposium topic from the list included in this Call for Papers along with the appropriate special topic if appropriate;

(I) Attach a PDF of your technical summary and then click on "submit."

If you need further information, please contact Bill Klein at [wklein@pcm411.com](mailto:wklein@pcm411.com) or Jay Morreale at [jmorreale@pcm411.com](mailto:jmorreale@pcm411.com).

### Submission Timetable

The deadline for receipt of abstracts and technical summaries is December 1, 2017. Notification of acceptance will be e-mailed by February 9, 2018. (The deadline for late-news papers is January 19, 2018; notification of acceptance, February 16, 2018). Authors of accepted papers will be directed to an online "Authors Kit" with instructions for the preparation of the paper to be published in the Symposium Digest. The paper shall consist of four pages, including all illustrations, and is due March 2, 2018 (March 16, 2018 for Late-News Papers).

### Points of Contact

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## Format of Presentations

Oral presentations will conform to a 20-minute format (15 minutes for presentation and 5 minutes for questions and answers). This year's Poster Session will be held late Thursday afternoon, May 24, between 5:00 and 8:00 pm. Accepted papers will be assigned to either oral or poster presentation at the discretion of the program committee.

## Student Travel Grants

A limited number of student travel grants, up to \$1000 each, will be made available to student presenters of accepted papers. A student travel grant must be requested upon submission of abstracts by checking off the appropriate box on the online submission site. A questionnaire will automatically be generated. Please complete the questionnaire. Only students who submit the questionnaire will be eligible to receive a student travel grant. The deadline for the submission of abstracts is December 1, 2017; January 19, 2018 for Late-News Papers.

## Late-News Papers

A portion of the Symposium schedule will be reserved for Late-News Papers. These papers should describe the results of late-breaking and significant developments that merit special consideration for attention at the Symposium.

The deadline for Late-News Papers is January 19, 2018. Late-News Papers must follow the format described for regular submissions to the Symposium (see page 1). Additionally, authors should include a statement describing why their paper deserves late-news status. **Only a limited number of Late-News Papers will be accepted.** Authors of accepted presentations must also submit a paper for inclusion in the SID Digest. Papers accepted for oral presentation will be assigned 10- or 20-minute slots depending upon available time slots.

## Speaker Responsibilities

All costs associated with your participation at Display Week as a speaker or invited speaker will be at your own expense (including, travel, housing, registration fee, etc.).

## Poster Session

Poster sessions present the opportunity for a more interactive dialog between authors and the audience. A successful poster paper should be a high-quality innovative paper where the poster presentation format would promote the exchange of detailed information between specialists. Papers where the demonstration of a new technology, concept, or phenomenon can complement the presentation are particularly suitable for the poster format and are encouraged.

Submission requirements and review criteria are the same for both oral presentation and poster formats, and these two formats receive equivalent publication in the SID Digest of Technical Papers. As indicated under "Format of Submissions," authors may state their preference for a poster or an oral paper presentation; however, the final assignment of accepted papers will be at the discretion of the program committee. Poster presenters are requested not to distribute handouts other than business cards.

## Deadlines and Key Dates

Abstract/Technical Summary . . . . .	Dec. 1, 2017
Late-News Abstract/Technical Summary . . . . .	Jan. 19, 2018
Accept/Reject Letters . . . . .	Feb. 9, 2018
Late-News Accept/Reject Letters . . . . .	Feb. 16, 2018
Digest Paper Submission . . . . .	Mar. 2, 2018
Late-News Digest Submission . . . . .	Mar. 16, 2018
Display Week 2018 . . . . .	May 20–25, 2018
Sunday Short Courses . . . . .	May 20, 2018
Monday Technical Seminars . . . . .	May 21, 2018
Business Conference. . . . .	May 21, 2018
Investors Conference. . . . .	May 22, 2018
Market Focus Conferences. . . . .	May 22 & 23, 2018
Exhibition / I-Zone . . . . .	May 22–24, 2018
Vendor Forum . . . . .	May 22–24, 2018
Symposium . . . . .	May 22–25, 2018

## Special Topics for 2018

The 2018 DW Symposium will be placing special emphasis on three Special Topics of Interest to address the rapid growth of the field of information display in the following areas: **Augmented Reality, Virtual Reality, and Artificial Intelligence; Quantum Dots and Micro-LEDs; and Wearable Displays, Sensors, and Devices.** Submissions relating to these special topics are highly encouraged.

### 1: AUGMENTED REALITY, VIRTUAL REALITY, AND ARTIFICIAL INTELLIGENCE

This special topic will cover the technologies and applications in the emerging areas of Augmented Reality (AR), Virtual Reality (VR), and Artificial Intelligence (AI). These sessions will bring together scientists, engineers, business professionals, market analysts, and industry leaders involved in AR, VR, and AI technologies, products, applications, advanced developments, and emerging trends.

- **AR and VR Systems and Applications**
- **Display Technologies for AR and VR Systems**
- **Spatial Sensing and Imaging Technologies**
- **Tracking, Localization, Mapping, and Navigation Techniques**
- **Computation, Graphics, and Display Processing**
- **Mapping and Rendering of Virtual Objects onto the Physical World**
- **Immersive Audio Technologies**
- **End-to-End System Integration and Latencies**
- **Inputs, Interfaces, and Interactions**
- **Human Factors and User-Experience Considerations**
- **Object, Human, and Scene Capture; Reconstruction, Recognition, and Understanding**
- **Machine Learning Techniques including Deep Neural Networks**
- **Biometrics and User Authentication**

### 2: QUANTUM DOTS AND MICRO-LEDs

This technology track will focus on inorganic-semiconductor-based materials and device innovations for display applications. Papers are solicited in the following areas:

- **Nanomaterials:** Semiconductor quantum particle (dots, rods, etc.) synthesis and development of nanocomposite formulations. Optimizing process ability and integration, optoelectronic properties, and reliability.
- **Electroluminescence and Applications** – Using quantum nanomaterials in emissive displays. Technology innovations related to nanomaterial electroluminescence (color purity, lifetime, efficiency), RGB pixel patterning and heterostructure integration, and device innovations related to implementation in top- and bottom-emitting structures.
- **Photoluminescence and Applications** – Using quantum nanomaterials for color-conversion applications in display components and in pixel-integrated configurations. Optimizing performance and stability for integration on-chip (inside LED package) and in remote phosphor configurations for backlight units.
- **Micro-Inorganic-LEDs and Applications** – Emerging technologies based on scaling down inorganic LEDs for use as arrayed emitters in display applications, with opportunities from large video displays down to high-resolution microdisplays. Science and technology of micro-LED devices, materials, and processes for the fabrication and integration with electronic-drive backplanes. Color generation, performance, and stability. Packaging and module assembly solutions for emerging applications.

### 3. WEARABLE DISPLAYS, SENSORS, AND DEVICES

This special track will cover all aspects of wearable displays including product and process design, user applications, wearable system integration, and display technologies. As the next step in the mobile computing revolution, wearables have emerged as one of the most active fields in the technological world. Being the most mobile and personal form of technology to the users, wearable devices present many possibilities, and at the same time many uncertainties. This special track will provide a platform for researchers, designers, engineers, and anyone involved in wearable displays to share recent advancement and challenges. The topics covered include, but not limited to, the following:

- **Wearable Product Design and Concepts**
- **Wearable Applications**
- **Wearable Display Requirements including Readability and Durability in Extreme Environments**
- **Advanced Displays for Wearable Applications including Low Power, Flexible, Stretchable, Textile, and Others**
- **Wearable-Display Processes**
- **Directive-View Wearable Displays**
- **Microdisplay Design Suitable for Wearable Applications such as Head-Mounted Displays**
- **Fashion and Wearable Displays**
- **Wearable Sensors Integrated with Displays**
- **Wearable Devices with IoT and Health Applications**

## Symposium Topics

As growing and multi-faceted fields, work relating to the special topics can fit under a number of different symposium topics, including Active-Matrix Displays, Applied Vision/Human Factors, Display Electronics, Display Manufacturing, Display Measurement, Display Systems, Emerging Applications, Emissive Displays, e-Paper and Flexible Displays, Lighting, Liquid-Crystal Technology, OLEDs, Touch and Interactivity, and Automotive/Vehicular Displays and HMI Technologies. While the special topical sessions will be arranged in a unified program for the benefit of attendees, authors should indicate the appropriate symposium topic for their abstract in addition to the special-topic designation (if appropriate).

The Society for Information Display (SID) encourages the submission of original papers on all aspects of the research, engineering, application, evaluation, and utilization of displays. Display Week 2018 will feature special topical sessions that focus specifically on selected issues or key developments. Paper submissions are welcome for any of the general symposium topics or any of the specific topical sessions.

The Society plans to include coverage of every aspect of display technology and applications, especially the emergence of AR/VR and Vehicular Displays. Special attention will also be given to all aspects of novel input technologies for displays. Papers are solicited in all aspects of motion-image technology, including device technology and related system technology. Papers are also solicited in the area of technology development that enables lower power consumption and higher-performance displays for mobile devices (smartphones, tablets, e-books, etc.).

**Active-Matrix Devices:** Papers on advances in the implementation of active-matrix electronics into displays and other related systems as well as on all aspects of TFTs, including devices with new structures/processing, reliability, circuit design, and novel applications, are solicited.

**Applied Vision / Human Factors:** New display technology has driven displays to have more pixels, greater contrast, higher brightness, and richer color volume, thus enabling a wide range of new visual experiences. Submissions are encouraged that discuss the benefits and tradeoffs of how these new display technologies as well as novel uses of traditional display technology can have a measurable impact on the visual experience. Topics in the following areas are particularly in demand: mitigating the challenges by presenting comfortable and engaging 3D imagery (including autostereoscopic, AR, and VR form factors), effective use of a wider color volume to create a more immersive and compelling experience, and approaches to take advantage of limitations of the visual system to process or transmit display data more efficiently. Papers that discuss novel methods of user interaction and HMI with display systems are also welcomed.

**Display Electronics:** All aspects of circuits (integrated or otherwise) for displays, electronic components for displays and imaging devices, and image- and video-processing algorithms.

**Display Manufacturing:** Materials, process, and equipment advancements related to the manufacture of display panels, components, and module assemblies.

**Display Measurement:** Characterization and measurements of displays and display components.

**Display Systems:** Papers on the novel integration of displays into specialized devices as well as system-level aspects of electronic displays are solicited.

**Emerging Applications:** Advances in the development, use, and characterization of display technologies, components, solid-state lighting, and of systems resulting in new capabilities, improved performance, or better user experience in (i) existing display implemented into novel applications (e.g., consumer, industrial, commercial, medical, and security) or (ii) novel or emerging uses of display and lighting-related applications.

**e-Paper and Flexible Displays:** All aspects of e-Paper, flexible, and wearable display technologies, including flexible, bendable, foldable, or rollable display devices (OLED, electrophoretic, MEMS, cholesteric LCD, electro-wetting, and other novel emissive and reflective display devices) and system-level integration of such devices and printed electronics based on organic and inorganic materials. Advances in flexible-display materials (substrates, transparent conductors, TFTs, barrier layers, and adhesives), printing and novel deposition techniques, manufacturing methods (R2R, bonding or liftoff), electro-optical effects, sensor technologies, driving techniques, device performance and reliability, ergonomics, and applications for emerging paper-like, flexible, wearable, or stretchable display technologies are sought.

**Lighting:** All aspects of solid-state lighting with focus on advances in materials and devices, visual and non-visual effects of lighting, smart lighting and intelligent luminaires, and implementation and application of dynamically color-tunable lighting. Trends and technologies for future lighting solutions and alternative light sources.

**Liquid-Crystal Technology:** Advances in the development of liquid crystal, including electro-optical effects, materials, and devices.

**Organic Light-Emitting Diodes (OLEDs):** Papers on materials, display designs, and performance of small-to-large-area panels are sought. Papers that discuss the progress and challenges of OLED display performance and manufacturing issues are of particular interest. Furthermore, papers on OLED signage and OLED lighting solutions are welcome.

**Touch and Interactive Displays:** Advances in touch-screen technologies, applications, driving electronics, system integration, and human interactions. The advanced materials and process technologies associated with touch design and applications will be also covered.

**Automotive/Vehicular Displays and HMI Technologies:** Papers on advances in display and touch-screen technologies, applications, electronics, system integration, and human interactions, including user experience and interfaces, are solicited. Papers on advanced materials and technologies associated with automotive topics and applications are also encouraged.

As part of the technical symposium covering the broad range of information-display topics listed, Display Week 2018 will feature topical sessions which focus specifically on selected issues or key developments. Paper submissions are welcome for any of the general symposium topics or for any of the specific topical sessions described below.

## ACTIVE-MATRIX DEVICES

### TFT Devices Made of LTPS, Oxide, and Other Semiconductors

Si-based FETs have a long history, but LTPS TFTs are still one of the hottest topics in backplane technology because of their superior electrical performance. As a strong competitor to LTPS, oxide-semiconductor technology is emerging and continues to improve in several aspects, including stability (over time, temperature, and light), uniformity, mobility, etc. Other alternative semiconductors are emerging, including 2D materials. With proper process control, the 2D materials may provide electrical properties ranging from conducting to insulating. Hybrid TFTs, offering the potential of combining the advantages of different TFT technologies, represents a new development of interest. Papers on all aspects of TFT technologies and application are solicited.

### High-Performance Active-Matrix Displays

The trend of display technology is moving to higher resolution and frame rate for better visual experience. Particularly, the ultra-high-resolution displays with large pixel numbers over 4K x 2K or large pixel density (e.g., >800 ppi or even >2000 ppi) have drawn more and more interest. Together with high frame rate (e.g., >120 Hz), there are many technical issues to be overcome. TFTs with high mobility or resolution, pixel circuits, and integrated circuits for high-speed operation, techniques to solve the RC delay issues, and any topics that related to the realization of high-performance display are solicited.

### Ultra-Low-Power Active-Matrix Displays

Ultra-low-power consumption is extremely important for any portable displays, including handhelds and notebook PCs. Ultra-low-power technologies include, but are not limited to, super-high-aperture TFTs, high panel transmittance, highly efficient backlighting, dynamic backlighting, low- $V_{th}$  LC material, charge sharing or recycling, step charging, new driving schemes, low-digital-voltage, bistable display devices, pixel memory, partial updating, highly reflective displays, etc. Papers are particularly encouraged in this area.

### New AMOLED Display Pixels and Backplanes

Organic LEDs have been a focal point in the display industry because of their superb image quality and slim form factor. However, AMOLED displays must overcome the following obstacles in order to achieve high-volume production: differential aging, image burning, power consumption, backplane consistency, manufacturability, and cost. Progress is being made on many of these fronts and on improving maximum brightness for daylight readability. Papers related to AMOLED display technologies, such as pixel structure, circuitry, and driving scheme, with an emphasis on its backplane advances, are solicited.

### Novel TFT Circuits and Driving Technologies

The growing emphasis on higher-quality displays has led to numerous development efforts for pixel and peripheral circuits made by TFTs. Moreover, the high performance of new TFT processes enables the monolithic integration of analog and digital display driver circuits as well as other peripheral and novel functions on the active-matrix-display substrate. Papers that advance the integration of peripheral circuits and systems into active-matrix backplanes are solicited. Papers on driving technologies based on active-matrix devices, especially addressing novel pixel structures coupled with a required new driving scheme are encouraged. Papers on measurement results compared with circuit simulation results with up-to-date models are encouraged.

## Sensor-Integrated Active-Matrix Devices

Active-matrix displays with in-cell-touch sensors are becoming popular, and finger-print-reader and force-touch sensors are beginning to be integrated under/in/on panels. Papers that advance the state of the art of active-matrix displays with integrated sensors are solicited. Moreover, flat-panel imagers for medical x-ray imaging can now be manufactured with active-matrix devices. Papers that describe the process, design, pixel circuits, and readout electronics for achieving the required performance and wide dynamic range are solicited.

## Emerging Active-Matrix Displays and Devices

Developers of active-matrix displays continue to push the limits of the physical design and manufacturing on both small and large extremes. One example is active-matrix devices and displays with low-temperature processes on flexible substrate. This contribution may include process with chemical compatibility, dimensional-tolerance control due to the thermal-coefficient difference both during the process and the usage and cost. Papers are solicited on displays and devices based on novel materials and designs or emerging applications

## APPLIED VISION / HUMAN FACTORS

### Wide Color Gamut and High-Dynamic-Range Imaging

Content is beginning to be produced with wider color gamut and high-dynamic-range encoding. Displays are rapidly catching up to better reconstruct this content. Submissions are solicited that discuss the types of signal processing carried out on this HDR data to optimize it for the viewing experience are strongly encouraged. Also, welcome are any studies that demonstrate the perceptual importance of the expanded range of brightness levels or color enabled by these new systems.

- Tone mapping
- Gamut remapping strategies
- Perception of brightness and color
- Optimization of ambient lighting
- Benefits of HDR imaging for mobile applications
- Impact on visual quality of HDR imaging formats and work flows

### Visual Comfort of 3D Images in Wearable Displays

Current stereoscopic or 3D display technologies and content often provide visual cues that differ significantly from the visual cues in our natural viewing environment. Submissions which discuss the impact of virtual- and augmented-reality display technologies on viewer performance, engagement, enjoyment, comfort, and fatigue are encouraged. Included are proposals and evaluations of novel evaluation techniques, novel technologies for improving specific aspects of the human experience, and studies quantifying the effect of display parameters, system configurations, and content generation technologies.

- Methods for quantifying comfort and eye strain
- New applications of head-mounted-display technology
- Novel technologies for improving the human experience
- Evaluation of display parameters and system configurations on user performance
- Evaluation of new human-computer interaction methods with virtual content
- Evaluation of vision and human factors on holographic displays

## Immersive Interaction and New Human–Machine Interfaces

New types of displays enable new forms of interaction. Major advances are being made in areas of projective, head-mounted, and large-format displays system. Papers are strongly encouraged that explore how these new technologies can and will be used to foster new immersive experiences. These can include how new forms of interaction increase excitement, productivity, or enable new applications.

- Position tracking systems for hands and head in VR/AR systems
- Optical tracking systems for use with direct-view display systems
- Camera-based systems used in conjunction with projective displays
- New detection paradigms for touch and gesture
- Development or evaluation of user paradigms involving touch, gesture, and haptic input

## Image Quality and Display Perception

Papers are sought discussing all aspects of display perception and image quality. Topics in this category include papers concerning color management, image-quality metrics and human-vision models, efficacy of image compression, and impact of video artifacts on display quality.

- Models of human tone and color perception, including color-appearance models
- Quality management in the imaging pipeline (e.g., from camera to display)
- Perception of ultra-high resolution
- Image-quality metrics and human-vision models
- Impact of video artifacts on perceived quality

## Human Factors in Emerging Displays

Going beyond flat-panel displays, how do curved, transparent, and new form factors enable new types of visual experiences. Submissions within this area are expected to explicitly illustrate the impact or issues of human vision or behavior for any of the emerging displays, or emerging display applications.

- Wearable displays, including smart glasses and smart watches
- Immersive displays, including curved displays and super-high-resolution (> 4K x 2K) displays
- High-reflectance displays, including reflective MEMS and e-paper
- Medical displays and images
- Flexible/bendable/foldable displays
- Transparent displays

## Lighting and Adaptation

Submissions are sought which explore the impact of display illumination, interactions of ambient and display illumination, and novel methods for producing luminance from a display on user performance and comfort. Of particular interest are papers that discuss the interaction of a display with the ambient-lighting environment. Submissions should concentrate on the design and evaluation of illumination sources for enhancing the human experience. Included are models and metrics of human perception, novel system designs that demonstratively enhance the impact of these systems on user performance and comfort, and studies quantifying the effect of lighting and illumination conditions on the user experience.

- Perception of displays in dynamic or bright ambient conditions
- Design of display lighting systems based upon user performance models and metrics
- Impact of ambient conditions on display performance
- Evaluation of the impact of display lighting systems on human performance
- Impact of glare on displays for human vision

## Human Factors of Projection Systems and Applications

Submissions describing how new projection technologies can enhance the audience experience. Topics including how laser-projection, super-resolution, and stereoscopic projection systems lead to superior image quality are strongly encouraged.

- Narrow-band laser primaries
- Spectral metamerism
- Contrast perception
- Cross-modal interaction (combination of motion, scents, vibration, immersive audio)
- Preferred brightness

## DISPLAY ELECTRONICS

### Electronics and Image Processing for Wearable Displays

Wearable displays are one of the fastest growing areas in both consumer products and technological development. Thanks to advancement in low-power advanced RF technology, advanced microprocessor technology, and advanced display technology, the push for super-mobile applications is increasingly close to realization, especially for applications in augmented reality (AR) and virtual reality (VR). This topic will cover the emerging electronics development in wearable-display products, application, and technologies. Specific topics of interest include:

- Ultra-low-power electronics taking advantage of natural energy harvesting
- Image compression and processing for glass-type near-to-eye systems (including AR and VR)
- Attention-control display technologies
- Flexible display electronics for wearable displays
- Wearable sensing electronics
- Power management of wearable displays

### Driving Electronics for Ultra-High Definition (4K x 2K and Beyond)

Displays with resolution that is higher than FHD (1920 x 1080) have been one of the biggest issues for next-generation televisions and mobile devices. A relentless push for super-high-resolution image content is requiring rapid evolution of displays. New issues need to be solved to implement displays with these higher resolutions. Papers are solicited that deal with system architecture, interface design, driving circuits, and algorithms that will enable higher-resolution displays such as 4K x 2K and beyond.

### Driving and Compensation Circuits for Curved Displays

One of the key recent trends in display applications is curved display surfaces, ranging from large-format TVs offering immersive visual experiences to small-size displays enabling new mobile form factors and wearable devices. Papers are solicited that address the electronic driving, control, and compensation techniques for curved displays, including both large and small displays, technologies spanning LCDs, OLEDs, other emerging displays, and any special image capture and processing techniques for curved displays.

### Electronics for Touch and Interactive Displays

The ways we interface and interact with the visual display content on the computing, communications, and entertainment devices are changing, with natural user inputs based on touch, gesture, voice, and multimodal technologies replacing or augmenting the use of traditional user interfaces based on keyboard, mouse, trackballs, and joysticks. Touch technology is already ubiquitous, especially on mobile devices, with annual shipments of touch screens well exceeding a billion units. We are now witnessing early proliferation of voice interfaces on mobile devices, gesture interfaces on consoles, and other form factors. This transition to natural and intuitive user interfaces is ushering in a new class of highly interactive and exciting applications and user experiences.

This topic will include papers on the electronic subsystems for interactive displays, including sensors, algorithms, processing, user interfaces, and applications.

### **OLED Driving Techniques**

AMOLED displays have been greatly improved and impacted mobile applications in recent years. Moreover, panel makers are focusing on large-sized television applications of AMOLEDs. They are facing many issues such as  $V_{th}$  compensation, low-power operations, 3D applications, high resolution, large-sized implementation, *etc.* Papers are solicited that deal with system architecture, interface design, and driving circuits and algorithms that will enable advanced AMOLED displays regardless of the panel size.

### **Display Drivers, TCONs, and New Driving Schemes**

Despite the maturity of matrix-driven displays, there is no limit to improvements in the driving convention, particularly with new demands such as high refresh rate and large-area driving, high bit-depth, and crisp rendition of moving images. In addition, emissive displays, such as LEDs, PDPs, and OLEDs, have some major advantages over non-emissive displays, such as LCDs and LCoS displays. However, these displays require different driver performance and driving schemes than non-emissive displays. Papers should cover the advancements in drive schemes, intra-panel interconnects, and novel features, architectures, or circuits of driver and timing-controller ICs required to provide the best image quality for various types of displays.

### **Driving Circuits integrated on Glass**

More and more driving circuitry is being integrated into the panel fabrication itself, specifically for row drivers. Papers in this topic should address the design and performance of integrated drive circuits for FPDs using all types of TFTs including amorphous/poly-crystalline/single-crystal silicon TFTs, organic TFTs, and oxide TFTs, *etc.* Papers dealing with architectural and system-partitioning issues, yield and cost impact, low-power circuit structure, vertical stack-up for less capacitive loading, and performance limitations as well as detailed circuit design approaches are solicited.

### **High-Speed Interface**

As the resolution of displays increases especially in mobile and TV applications, required data rate of display interfaces becomes higher and higher. Low power consumption and low RF noise emission are essential requirements for long battery life and wireless connectivity of mobile applications. Papers are solicited that deals with interface between a graphic source and a stand-alone display device, an image processing board and a display panel, intra-panel interface between a timing controller and driver ICs. In addition, transmitters/receivers/transceivers, equalization techniques for off-chip interconnection such as signal channels over multiple PCBs or a panel glass, and image data compression algorithms for interfaces are encouraged.

### **Low-Power Low-Cost Driving Technologies**

The need for lower-power displays has been the major driving force behind the development of many FPD technologies, mainly in the portable/mobile display area. But low power is also gaining importance in large-display applications while display performance requirements are intact or required to be even better. Besides, low-power mobile applications present constraints for display-system design that is entirely different from most other applications. This leads to ICs that are designed specifically for mobile displays, dealing, for example, with different display specifications, a broad application space, optimizations for varying ambient conditions, micro-power circuits for systems with super-low-power reflective displays, and, of course, low cost. Papers are solicited that deal with system architecture, interface design, and driving circuits and algorithms that will reduce display power consumption and implementation cost, as well as the latest developments in mobile-display electronics, ranging from ICs and system integration to specific electronic components.

### **Image/Video Capture and Processing Techniques**

Image quality remains one of the most important market drivers for any display application, with the capture, processing, and display all playing crucial roles. The image quality on the display can be optimized by improving the display as well as by applying suitable image- and video-processing algorithms. This processing depends on the nature of the content captured as well as the characteristics of the display used. Papers are solicited that address capture or display-specific video-processing algorithms and circuits. General processing includes, but is not limited to, MPEG (de)coding, noise reduction, de-interlacing, scaling, contrast, sharpness and color enhancement, and frame-rate conversion. In particular, papers are solicited that go beyond this general video and image capture and processing and address various capture and display specific aspects, such as motion-artifact reduction, viewing-angle improvement, lifetime improvement, *etc.*

### **3D/Depth Imaging and Augmented/Virtual Reality**

While contents based on 2D imaging have formed the backbone of today's display applications, depth-imaging technologies are advancing very rapidly, which are enabling new 3D interactive applications with life-like augmented and virtual reality. These technologies are allowing real-time superimposition of virtually rendered 3D objects on the 3D world. One of the important requirements towards providing compelling user experiences for augmented-reality applications are projection mapping technologies with visually consistent cues. Papers are solicited on the topics of depth-imaging, augmented- and virtual-reality applications, including correct mapping and rendering of augmented objects on the real world.

### **High-Dynamic-Range Driving Electronics**

The key benefit behind high-dynamic-range (HDR) displays is that the image is more realistic due to a higher level of contrast between light and dark images on the screen. One of the key trends is to produce HDR-capable displays, which requires major technical advancement to enable HDR. Papers are solicited on the topics of key enabling technologies in the display driving electronics.

## **DISPLAY MANUFACTURING**

### **Manufacturing-Related Advances Enabling Current and Emerging Displays (including Flexible, Foldable, Wearable, or Stretchable Devices; 3D or Transparent Displays; Multifunctional Display Architectures, *etc.*)**

These sessions will focus on manufacturing related developments enabling new display technologies and form factors, along with the incorporation of added functionalities. This may include 3D displays, transparent displays, sensor-integrated display panels (*e.g.*, touch sensing, optical sensing, *etc.*), as well as novel approaches for manufacturing of existing displays.

### **Manufacture of High-Resolution OLED and Other Emissive Display Panels**

These sessions aim to cover broadly the advances in the manufacture of emissive displays. In particular, papers on enablers of lower manufacturing costs of OLED panels are strongly encouraged – equipment, process, and materials advances as related to LTPS or Oxide TFT backplanes, pixel-array fabrication, high-resolution patterning with Fine Metal Mak (FMM), OLED Evaporation or Patterning Systems and Thin Film Encapsulation (TFE), packaging solutions, *etc.* More generally, papers relating to the manufacture of other emissive technologies are encouraged, including emerging technologies such as quantum-dot LED based displays.



### **Manufacture of Active-Matrix LCDs and Other Non-Emissive Display Panels**

Papers are solicited on topics related to the manufacture of active-matrix backplanes, including innovations in oxide TFTs and poly-Si, as well as conventional a-Si technologies. Examples of manufacturing innovations include process and equipment optimization, mask/complexity reduction, TACT time or yield improvements, and reduction of materials consumption. Other topics include the logistics of substrate handling and processing, overall factory layout, and present significant manufacturing challenges. In addition to the above topics, papers describing advances in the manufacture of other non-emissive displays such as DLP MEMS-based displays are solicited.

### **Manufacture of e-Paper and Other Reflective Displays**

Papers are solicited on topics related to the manufacture of reflective displays, such as electrophoretic, electrowetting, electrochromic, MEMS-based displays, etc. Particular areas of interest include pixel-array manufacturing and packaging/encapsulation solutions for rigid and for flexible panels. Additionally, papers describing advances in materials, processes, and equipment that enable high-volume manufacturing for this newer family of displays are encouraged.

### **Manufacturing Large-Sized Displays Including Manufacturing Equipment and Processes for TFT Device Manufacture (Gen 10.5 and Above)**

Papers are solicited on the topics related to the technical challenges associated with processing large-sized displays with very large substrate (Gen 10.5 and above) for cost-effective display device manufacture. Processes and assembly concepts for cost-effective displays of decameter sizes including roll-to-roll processes, shadow masking, multi-beam Laser processing, etc.

### **Manufacturing Equipment for Front-End and Back-End Processing, Including Packaging, Encapsulation, Interconnect, Assembly, and Roll-to-Roll Processing**

The advent of new display types, shapes, and features often require the development of new processing equipment and techniques. These sessions will focus on the development and application of new designs or unique adaptations of equipment for the manufacture of displays. Possible topics include equipment advances in the areas of robotic handling, thin-film deposition and patterning, roll-to-roll printing, flexible films, spacer construction, and/or application. Papers applying printing methods in display manufacturing are encouraged.

### **Display Module Manufacturing including Panel and Module Assembly for All Display Technologies**

AMLCDs, flexible and foldable OLED displays, e-Paper, projection displays, and other emissive and non-emissive displays, including MEMS as well as other display types, each have individual assembly and packaging requirements. Papers describing display-module assembly, including plate-to-plate alignment and encapsulation techniques, interconnect technologies such as ACF, and other flex and chip attach methods will be addressed. Furthermore, papers are encouraged on topics related to materials, processes, and equipment enabling module assembly of display panels and associated components, including touch panels, backlights, cover glasses, etc.

### **In-Line Manufacturing Test, Repair, and Metrology.**

Papers addressing final assembly, test, repair, as well as in-line testing and production-yield monitoring are of interest for this session. Papers are requested covering technology advances for the manufacture and handling of very large TFT glass substrates and how this relates to both equipment and factory design, impacting test and repair methods and yields. Testing of smaller displays such as for the cell-phone market may have a different

set of manufacturing test requirements; advances in these areas for yield improvements, new methods, and cost reduction techniques are also encouraged. Also of particular interest are developments in the areas of automated optical inspection (AOI) and array repair.

### **Display Component Manufacturing (e.g., Optical Films, Color Filters, LEDs, Backlights, In-Cell and On-Cell Touch Panels, Finger-Print Sensors, Cover Windows, etc.), Including Topics Related to High Brightness and True Black, HDR Display, and Quantum-Dot-Based Applications,**

Finished display products include a variety of components complementing the display panel in the target application. Papers focused on the manufacture of such components are encouraged, including touch sensors, backlight and frontlight light guides, optical films, protective cover glasses, and others. Papers are also encouraged in topics related to manufacturing scale-up for new technologies such as quantum-dot-based applications.

### **Manufacturing Productivity and Cost-Reduction of Various Displays**

Papers dealing with a systems approach to manufacturing efficiency improvement or cost reduction will be the focus of these sessions. Possible topics include cost reduction and systems integration, quality management and resource planning techniques, manufacturing economics, cost-of-ownership issues, and the human factors in display manufacturing. Additionally, alternate manufacturing techniques that provide significant productivity enhancements, such as roll-to-roll processing, are solicited.

### **Materials Including Substrates, Films, Adhesives, Photo-Patternable Organic Materials (for Bank Layers, Planarization Layers, etc.), Photoresists, and Other Consumables**

Materials developments to support the efforts of the display manufacturers are appropriate topics for these sessions. These topics include new substrate materials with new properties or new handling methods; improvements in consumable materials such as photoresists and sputter targets; and performance-enhancing materials such as sealing frits, desiccants, polarizers (including film and coated polymer types), optical enhancement films and photo-patternable organic materials for bank layers, planarization layers, etc. Of particular interest are papers dealing with materials for roll-to-roll and printing processes that relate to manufacturing improvements and manufacturing analysis.

### **Green Manufacturing.**

Papers are solicited on a broad range of topics related to reducing the environmental impact of displays, such as reducing material and energy consumption during manufacturing, waste management, as well as recycling strategies. Examples include equipment, process, and material innovations leading to improved material utilization and energy efficiency, studies on the design of new display manufacturing sites minimizing environmental impact, as well as papers aimed at the environmental considerations associated with display products end of life.

## DISPLAY MEASUREMENT

### Characterization of Perceptible Display Phenomena

Different physical and optical properties of various display technologies (e.g., LCD, OLED, projection, reflective, flexible, curved, etc.) make it difficult to design characterization methods that deliver consistent results across manufacturers and technologies. Papers are solicited which propose and evaluate measurement methods and resulting objective metrics for comparing the perceptible display phenomena and performance criteria among display technologies in similar applications in repeatable and understandable ways. Papers on the characterization of motion artifacts, high-ambient contrast and color performance – which are strongly dependent on display technology – are welcome.

### Optical Characterization of Display Materials and Components and Their Effects on System Optical Performance

Many display technologies benefit from advances in optical and functional components, such as light-steering films, diffusers, polarizers, retarders, color filters, front-of-screen elements, touch sensors, and optical coatings. These components impact optical performance – including luminance, contrast, viewing angle, color, and uniformity. The effects also include changes to display MTF and clarity (e.g., sparkle or haze), depending on component type, surface treatments, coatings, and assembly techniques. Papers are solicited that address the optical characterization of components and their impact at the system level.

### Optical Characterization and Measurement of High-Dynamic Range and Wide-Color-Gamut Displays

High-dynamic-range and wide-color-gamut display technologies are developing rapidly. HDR and WCG image capture, transmission, and display enable an unparalleled visual experience. Papers are solicited for the characterization and metrology of these new systems. Methods for establishing perceptually meaningful and sensible metrics for EOTF (gamma) and color volume are of special interest.

### Solid-State-Lighting Metrology and Characterization

LED and other solid-state-lighting technologies are making their way out of high-tech devices such as phones and laptops and into streetlights, automobiles, aircraft, luminaires and light bulbs. Papers are sought that highlight the unique measurement challenges of these new light sources. Characterization of power, efficiency, and the effects of the unique spectral power distribution of solid-state light sources on human physiology are topics of particular interest.

### Advances in Display Measurements Standards

Organizations such as the ICDM, ISO, IEC, and CEA are constantly proposing new methods and concepts in the field of display measurement to address characterization issues brought about by new technologies and applications. Authors are encouraged to submit papers that explore the performance and correlation of proposed methods from current or future international standards.

### Measurement Methods for Near-to-Eye Displays for AR, VR, and Other Applications

Applications such as augmented reality (AR), virtual reality (VR), TV, and medical imaging impose unique demands on the specific display technology and the methods used to characterize their performance. Certain display types such as near-to-eye and projection, for instance, use complex optical systems that require unique characterization considerations. Papers describing methods, experiences and results in this area are welcome.

## Optical Characterization and Measurement of Light-Field and 3D Displays

In addition to the traditional display optical characteristics that must be evaluated when describing the performance of light-field and other 3D displays, qualities related to 3D-specific functionality must be measured and described. Authors are encouraged to submit papers that are unique or of special interest to light-field and 3D display characterization.

### Calibration and Verification of Instrumentation

The field of display metrology benefits from the growing number of instrument developers and new devices. These benefits come with the challenge of verifying the accuracy and traceability of new instruments, as well as their suitability for a given task. Of special interest are procedures and simple diagnostics for on-site calibration. Authors are encouraged to submit papers which describe their recent work in calibrating, testing, and validating new instrumentation.

## DISPLAY SYSTEMS

### Display Systems

Display Systems employ a variety of electronic devices to harness a man to a machine via high-bandwidth pathway. The devices are sustained by a wide spectrum of advanced components. Novel developments in display system elevate the quality of communication. Papers on new technologies for display systems, modification or improvements of existing systems, real-time controlling or monitoring of operations, and system evaluations are of interest and solicited.

### Novel Displays

New and unconventional display systems of today are building blocks for the products of tomorrow. From microdisplays to handhelds to wall displays to projection systems, all sizes and novel approaches are of interest. Papers are solicited that describe new-concept display systems and may include novel devices, integration, or image processing.

### Mobile Displays

As we move toward an ever-more-connected society, mobile displays with increased size and resolution and improved optical parameters are becoming ubiquitous in smart phones, network-connected e-Readers, a wide range of consumer and enterprise communicators, and mobile Internet devices. All of these applications require low power, low weight, thinness, small overall volume, and increased mechanical durability while improving display visual performance. Unique system designs that improve and/or optimize any or all of these aspects of mobile displays are solicited.

### Wearable, Augmented-, and Virtual-Reality Displays

In the design of mobile devices, such as cell phones, conflicting criteria are present. On the one hand, there is a demand for increased display size and resolution so more information can be presented, while, on the other hand, there is a pressure to reduce the overall size and weight of devices and to increase battery life. Near-to-eye displays offer a compact and low-power solution that can provide large high-resolution imagery to users. Near-to-eye displays include bring-to-eye displays in advanced cell phones, compact systems for head-mounted displays used in mobile computing, electronic viewfinders for cameras, and personal theater systems. Other applications of near-to-eye displays, such as augmented reality, virtual reality, training/simulation, and computer gaming, demand higher resolution and greater field-of-view than mobile devices, yet reducing the size of these larger head-mounted displays is also a priority. Papers are solicited which address novel image sources, optical system designs, and integration of near-to-eye displays into these various devices.

### Ultra-Low-Power Displays

Energy saving is a key issue for display technologies. Decreased energy requirements are vital for mobile applications that run on limited battery capacity. Lower power consumption is also critical for non-mobile display technologies such as television, to conserve limited environmental resources. Papers are solicited that describe methods of energy saving in displays, reduction of power consumption during display operation, and related topics.

### Transparent Displays

As information displays become increasingly ubiquitous, transparent or see-through displays have the potential to enable new and innovative applications. Papers are solicited on transparent display technology and innovative display system designs that effectively integrate transparent displays for new applications.

### 3D, Autostereoscopic, Light-Field, Compressive, Volumetric, and Holographic Displays

Advanced 3D display techniques enable users to experience a full and natural sensation of depth, which can be useful in a wide range of applications. Providing a sense of depth in a natural manner can enhance the reality of the perceived images and also remove the issues that cause fatigue in traditional stereoscopic 3D. Recent developments in wearable displays and their application to augmented and virtual reality make 3D display techniques even more important. Papers are solicited across the full spectrum of 3D display technologies including stereoscopic, autostereoscopic, light-field, compressive, volumetric, and holographic display techniques with particular interest in the enhancement of viewing angle/resolution/depth range, reduction of vergence accommodation conflict, lessening of cross-talk, improvement in luminance, reduction in distortion for multiple viewers, improvements in system cost, as well as approaches managing the computational load of voxel, light-field, or holographic data. Papers related to the applications of the 3D display techniques to emerging display systems including near-to-eye displays, head-up displays, and eye-aberration-correcting displays are also solicited.

### Digital 2D/3D Signage

The use of digital signage has become prevalent in almost every public area indoors or outdoors. These include TV-size displays all the way up to very large video walls. Papers are solicited on systems and technology developed specifically for digital signage. This may include the use of 3D, contrast and luminance improvement for outdoor application of signage, sunlight-readable signage, wide-range dimming capability, mechanically strong signage to protect from tampering and vandalism, signage with a wide operating-temperature range, effective ways of utilizing a screen for transmission of multiple sets of information, signage operation systems, and related topics.

### Backlight Units (BLUs)

A BLU is an indispensable device for transmissive or transreflective LCDs. However, employing a BLU results in an increase in the power consumption as well as in the thickness of an LCD module. Papers on the following technologies are solicited: (i) functional light-guide plate (LGP) or light-guide film (LGF) for BLUs used in mobile displays, (ii) flexible BLUs, (iii) direct-view or edge-lit BLUs for LCD TV and monitors, (iv) power consumption reduction and thermal management, (v) solid-state light sources using BLUs with three primary colors or more for field-alternative LCDs, (vi) dynamic BLUs for high dynamic range (HDR), and (vii) monodirectional, multidirectional, or directional scanning BLUs.

### Frontlight Units (FLUs)

The reduction of power consumption in a display is an attractive and challenging theme. Reflective displays such as electronic paper (e-Paper), micro-electro-mechanical systems (MEMS), or micro-electro-optical-mechanical systems (MEOMS) based displays, and reflective LCDs have great advantages over the transmissive displays in terms of low power consumption, color gamut, and high contrast under bright ambient illumination. However, the optical characteristics deteriorate under a dim environment. Frontlighting a reflective display using an edge-lit light-guide plate is a unique method to modulate the displayed images and recover the optical characteristics under a dim environment. Since a frontlight unit is an indispensable unit for a reflective display in which the optical matching, efficiency, and image quality through the unit are of great interest, papers on FLU technologies and related components are solicited.

### Backlight/Frontlight Components

To achieve a slim structure having low power consumption and the wide color gamut of LCDs, advances in backlight-unit components, advent of novel materials, and adoption of more efficient-fabrication process are indispensable. Papers on novel optical components are solicited with particular interest in the following technologies: (i) novel optical components; quantum-dot films, quantum-dot capillaries, LEDs, lasers, light-guide plates (LGPs), prism films, diffuser films, and reflective films that have unique functions, structures, and high performances; (ii) optical-components-based novel materials such as unique phosphors, particles, coating materials, and zero-birefringence polymers; (iii) optical components fabricated by novel methods such as significantly thin LGPs by extrusion processes and integrated backlights by role-to-role processes. As it has been explained for backlight/frontlight systems, the reflective displays have great advantages over the transmissive displays in terms of low power consumption, color gamut, and high contrast under bright ambient illumination. The edge-lit FLU is a unique technology for lighting reflective displays. Papers on FLU technologies and related components are solicited.

### Novel Projection Architectures

Papers related to the system-level design of projection systems and light engines are encouraged, as are papers related to the design of the image-generating elements. In addition, papers related to the miniaturization of a projection system and the reduction of the power consumption of projectors are welcome.

### Individual Projectors and Multi-Projector Arrays

System-level papers related to individual projectors or projector arrays are welcome. Electronics to drive multi-projector arrays are included. Projection technology has expanded its reach in recent years at both ends: pico-projectors with low light output and intended for only a few viewers are at one end and large-venue and digital cinema projectors with ultra-high light output and intended for audiences up to thousands are both important to the industry.

### Emerging Applications for Projection Systems

Emerging applications often require new technologies and designs for the system to fulfill its intended purpose. Papers on unconventional applications of normal projection systems are solicited. Immersive and 3D visualization applications are important emerging applications for projection for both professional and consumer use. Papers on head-up displays (HUDs) and other systems that project virtual images are also strongly solicited.

### Novel Image Processing for Projectors

Projectors and projection systems require specific image processing solutions. Novel solutions and image-processing algorithms are very important. Papers on novel image processing for projectors and related technologies are solicited.

## Novel Components for Projectors

Novel Components for projection systems are built from an extremely diverse set of optical, mechanical, electronic, and electrical components. The components such as light sources, including short-arc lamps, lasers, LEDs, laser-phosphor conversion, quantum dots, and light-management optics such as filters and polarizers, are very important for front and rear projections. Papers on novel components for projectors are solicited.

## Projection Systems: Opto-Mechanical Design, Components, Lifetimes, Thermal Properties, Acoustic Noise

The projection-system design and novel technologies for thermal management of components including image-generating components, light sources, and light-management components such as polarizers are covered in this topic. Papers on projection systems including opto-mechanical designs, components, lifetimes, thermal properties and acoustic noise are solicited.

## Projection Mapping

The use of projection technology to illuminate non-traditional 'screen' surfaces has increased dramatically in recent years, with projection increasingly being used to bring to life building facades, cars, and other complex 3D geometries and surfaces. The current state of the art for the design and deployment of these experiences is largely manual and confined to 2D methods. Papers on techniques and methods to aid in the development and deployment of highly complex 3D projection mapping experiences are solicited. Topics can span any of the following areas: new projection-mapped content workflows, improved ease of setup techniques, accommodation for dynamic physical geometry, motion tracking, and interactivity.

## Large-Area-Display Technologies in Competition with Projection

Other large-area-display technologies such as LED videowalls and tiled displays that can provide large multi-viewer images. Papers on optical and electronic architectures, components, opto-mechanical design, calibration, signal distribution, human factors, manufacturing technology and other aspects of these displays are desired. Since most of these large-area displays are tiled, papers on novel solutions to problems of image processing, signal distribution and uniformity of tiled displays are welcome. Papers on novel applications, especially applications that cannot be filled by conventional projection systems, are welcome.

## Other Topics Related to the Design, Manufacture, or Application of Projection Systems, Subsystems, or Components

Papers on virtually any topic related to the design, manufacturing, and system-efficiency improvements through co-design of multiple subsystems are solicited.

## EMERGING APPLICATIONS

### Mobile Displays (Smartphones, Tablets, e-Readers, etc.)

Flat-panel-display technology is advancing rapidly. Displays are becoming increasingly mobile and rugged, higher resolution, more energy efficient, and higher light output. They can be worn or stored in both conventional and novel ways, and they can cover a wider range of sizes and formats. With these new capabilities, there will be emerging novel applications opportunities for mobile displays and display-related technology. Applications of mobile-display technology are also increasingly being utilized for an array of applications other than directly creating images for the eye. Applications already range from many types of handheld devices (smartphones and tablets) and laptop computers to electronic reading devices (e-Readers), micro-projectors, and an increasing array of both AR and VR devices. Flexible video and data displays are also on the horizon. Many mobile-display applications are moving toward higher resolutions and higher performance, creating unique issues to be resolved for small-format displays, flexible displays, and virtual-image applications as pressure mounts to create more energy-efficient devices. Improved power storage, data compression, and data-transfer capabilities are being developed for increasingly higher resolution and wireless applications. What new "emerging" applications opportunities can be created as mobile-display technology advances? How will solutions to various display challenges enable new applications opportunities? What new requirements must be satisfied to drive current displays through their next developmental steps for existing applications at higher added value to customers? What are probable future power, and massive data transfer requirements per square centimeter by application? How will improved-mobility play out in entertainment, games, lighting, any many novel applications not yet in the market?

### Wearable-Display Applications

As we reach the practical limits of data content on our handheld devices and as laptops get smaller for improved portability, a thirst remains for more data content and accessibility supported by increasing bandwidth, faster processors, and larger memory, driven by the rise of streaming high-definition entertainment. Advances in flexible-display technology and in display or photonics technology adapted to fashion and other product areas are likely to offer virtually unlimited creative opportunities beyond just novelty. What improvements or novel applications for sensor integration or tactile/physical feedback with wearable displays and light sources are on the horizon? Near-to eye displays offer a way for users to see large high-definition images in the smallest format package. The display capabilities of tablets, cell phones, smartphones, and handheld games are expanding rapidly. Full-color improved-performance 3D head-tracking compatibility for surround-view and reduced cost are key display parameters to support the growth of the personal-electronics markets. What technical market and consumer perception hurdles are needed for near-to-eye applications to move from mostly military and medical applications to become mainstream consumer products?

### Virtual- and Augmented-Reality Applications

Virtual reality (VR) has been thought of as the ultimate display technology for over 30 years. Augmented reality (AR) has the power to overlay data and even animation over your view of the natural world. Either VR and AR are best when combined with visualization, tactile, and other feedback mechanisms for an improved viewer experience. Making VR and AR systems smaller, more portable, more power efficient, and wireless, while improving the usable resolution, field of view, eye relief, eye box, and generally more compatible with human eyesight, is a goal of most serious AR/VR. Pupil-tracking, head-motion tracking, and orientation are improving. Some reasonable levels of success have been achieved in games,

simulators, and other head-mounted systems. Still, practical virtual-reality systems for the home PC platform have eluded the typical consumer. Many office and business applications could benefit greatly from the vast virtual-display area and potential portability of VR, so what impediments must be overcome for this to move mainstream? How to better network information and provide situational referencing to bring much of the hype applications that have been associated with augmented reality to become actual reality? What are initial acceptable cost-benefit consumer and commercial AR applications for market entry during the early adoption phase, beyond the limited maintenance and military applications? What is the status of the technology and what advances are on the horizon? What are the primary barriers to mass-market implementations of VR and AR? What are less obvious novel or initial commercial and consumer applications? What is the market potential for various applications?

### **3D, Stereoscopy, and Holography Applications**

Three-dimensional display systems are currently in use in medical modeling and CAD applications and are continuing to evolve and seek new markets. Major entertainment studios are currently pushing 3D content, opening the door for a new cinema experience. How will 3D or stereoscopic imaging impact entertainment and gaming? The television industry is following suit at the heels of the movie industry. What is the likely path by which this technology will be implemented and what are the current barriers to mainstream product applications? What is necessary for 3D to become a "must have"? Holography has also been quietly finding increasing applications over the past several years. What are some of these new instrument and imaging applications, and what are the technology solutions and potential killer applications needed for holography to reach into the mass markets other than non-video images on novelty items and product packages?

### **Touch and Distributed Displays Applications**

Touch screens have become common place from grocery check-outs to handheld phones, covering a broad range of industrial, commercial, and consumer applications. It has been estimated that the market for touch screens has been growing over 10% CAGR. Touch screens are now being adopted in home computers and laptops. Unseen applications might arise outside the current scope. What are some of the likely new market applications, and what not-so-obvious novel applications for touch screens might be coming? What technologies best fit some of these growing applications?

### **Avionics, Military, Automotive, and Ruggedized Display Applications**

The demands for greater functionality in rugged automotive military and avionics displays continue to evolve. Other outdoor applications require special displays or ruggedized commercial displays. Full-color wide-screen formats, headset and see-through displays, holographic displays, light displays, flexible displays, higher resolution, and increased brightness and contrast, as well as lower costs, are needed to meet these demands. How are we approaching the utilization of new and enhanced display technologies to meet emerging entertainment and gaming, user-friendly data access, improved visualization, industrial, business, military, police, emergency/rescue, and vehicular applications? Size, weight, portability, power usage/storage, data-content, and multifunctionality are all important considerations for many applications. Advances in these and other parameters will drive a vast range of new applications. What AR and VR applications are emerging as a result of the development of technology advancements? What display technologies are most suitable for harsh conditions? What new applications and environments are and can, in the future, be available for displays when suitably engineered devices are available?

### **Kiosks, Signage, Transparent, and Tiled Displays**

Applications of small-to-large-sized displays for signage, kiosks, and even shopping bags or carts for advertising and information messages are continuing to evolve in novel ways. The application can, on one hand, involve a monolithic display or a transparent screen, or on the other, several tiled flat-panel displays or projected images. Applications can be for indoor, outdoor, or bright illuminated indoor conditions. Tiling of displays with seamless abutting for command-and-control rooms, advertising, video lighting, and other applications are continually improving and appearing more seamless. What is coming next to excite us, and how far will electronic signage likely penetrate our supermarkets, malls, buildings, and roadways?

### **Digital Cinema, Entertainment, Gaming, and TV**

The era of e-cinema is upon us, with major studios releasing their features in digital form. The possibility for major cost reductions in digital production and distribution may restructure the entire industry. We are now seeing some of these transmission and media formats being implemented. Flat-panel TVs and curved-screen displays are now available at affordable prices, and viewing area, resolution, smart and wireless capabilities, and performance are steadily improving. What will be the future of entertainment and gaming displays? Which display technologies will share in these markets? How might they be implemented? What novel applications are emerging? Digital cinema is an opportunity to make optimal use of the strengths of digital display technologies. Multiple commercial and home-cinema applications exist. What are the best solutions to the data transmission and presentation issues? How to improve stereoscopic 3D in future digital cinema? What new features can be provided to improve the entertainment or communications experience?

### **Medical Displays**

Displays are broadly used in the medical profession to enhance information transfer and to access medical histories, to enable broader use of "telemedicine," and to enhance either diagnostics or therapeutics. The full range of emerging medical-display products and systems, from head-mounted systems to aid in surgery to high-resolution displays for x-ray diagnosis, will be discussed. What are likely formats for utilization of 3D, wearable computing, or holography for tomography imaging, endoscopy, or other medical applications? What new applications with wearable computer imaging and augmented reality will be available in future home or clinical-based medical products? What new applications are enabled in medicine by adoption of advanced display and new light-generation technologies? What are emerging novel applications using displays, sensors, and light-source technology as part of ELISA test arrays, pattern exposing or analysis of skin and other tissue, pathogen or toxin monitoring and analysis, and other diagnostic and therapeutic applications?

### **Multi-Modal Display User Interface (e.g., Auditory Displays)**

Displays for mobile applications, tablets, PCs, and entertainment are using interactive man-machine interfaces. Whereas personal information devices (PIDs) use single touch, smartphones, and other mobile applications use multi-touch and gestures interactively such that touch has become the dominant communication means to the devices. Utilizing the display surface as an audio source has been shown. What other applications of displays for physical displacement or vibration sources or sensors may be possible? Recently, other modes of inputs are progressing such as voice (auditory displays), gestures, and facial expressions (coming soon). Any mode of multi-modal displays, including "out of the box" concepts, will be considered for this category.

### **Display-Software Applications (e.g., Image Enhancement)**

Some applications of displays require enhancement of the displays performance. Increasing the number of gray levels and controlling their separation is one way to do that. Methods of dynamic backlight and algorithms of controlling gray levels will be

part of these applications. Motion-blur compensation for LCDs and image-enhancement techniques for quasi-static displays are becoming differentiating aspects in mobile markets. Optimization in variable ambient lighting conditions or image-processing methods such as edge enhancement will improve the visual experience. The use of dynamic backlights is a method to improve contrast and save energy, involving different methods and algorithms. Combinations of hardware, firmware, and software to improve image properties are welcome for this category.

### Smart Lighting / Solid-State Lighting

The solid-state-lighting (SSL) market has been gaining momentum and replacing incandescent and fluorescent lighting due to improved visible radiant power efficiency, durability and reliability, lifetime, spectral flexibility, and reduced heat generation. SSL has moved from display backlighting and LEDs to home, office, retail, and street lighting, to automotive headlamps, flashlights, holiday lighting, and many other applications (when properly implemented). Prices have been coming down rapidly, further accelerating market growth. Furthermore, SSL technology advancements are permitting users more choices of illumination spectrum as well as dynamic color-adjustable lighting and can enable more distributed multiple-source lighting in locations that were previously not practical. Non-visible LED lighting has been in use for surveillance camera applications and for surface pathogen control, but what other emerging applications for non-visible lighting and non-visible displays are emerging. How will the technical issues of thermal management, improved reliability, controls, and power supplies currently being addressed affect the development and deployment of higher efficiency and lower-cost LED, OLED, and other technologies for SSL applications? What new product designs and applications will be made practical by super-long-life lighting products (e.g., products not designed for bulb replacement) and how will the CFL, LED, OLED, and other SSL technologies likely play out against each other? How can we take advantage of the low-voltage driving to make dynamic, programmable, and other "smart" lighting?

### Environmentally Friendly (Green) Displays

Display technology has been advancing to provide better resolution, larger size, and performance for less cost. Energy efficiency becomes especially important for large-screen and, on the other hand, mobile applications. Materials of construction and end-of-life disposal have already created major issues for CRTs already, so how do we make the new displays more environmentally friendly at end-of-life? The continually changing and varied regulations around the world to protect the environment can be challenging. Will shifting from mercury-containing CFLs to solid-state-lighting backlights or OLEDs improve customer acceptance of "green" displays? How will consumers relate product price to energy savings, except as it affects mobile-product battery life? What are the anticipated initial production and end-of-life issues for the display industry and how can these be better addressed? Will there be new display applications to replace non-display means of information dissemination with new environmentally friendly displays? What emerging applications of display and solid-state lighting technology can enable new ways to keep the planet clean and safe?

### Ubiquitous Displays

The convergence of increasingly sophisticated display technologies, wireless communications, miniaturization, and interactive media facilitates evolution from passive desktop-centric computing to a new disruptive ubiquitous display environment. The media and visual content will support a diverse variety of display devices that can enable users to seamlessly interact with information. The display would become an active part of the workspace interacting between the user, data, environment, and other displays. For example, a smart refrigerator may be able to be cognizant of its contents, monitoring freshness, warning of outdated items, and

planning menus from food on hand. Personal biometric monitors could imperceptibly modulate heating and cooling, and illumination settings for an individual. Computers could be embedded into wristwatches, clothing, walls, and objects of all sizes to facilitate targeted interactive media. What innovations are required to make the concept of ubiquitous displays a reality? What novel methodologies are being applied to achieve the desired capabilities of ubiquitous displays? What kind of applications are being investigated or envisioned?

### Novel and Emerging Applications

Truly novel, emerging, and/or other unique display-related technology can offer an opportunity to solve issues that many may not even realize as issues until a solution is presented. What unique imaging applications can be brought to reality and what opportunities exist for displays and virtual imaging that have eluded the common path of display technology development? From microdisplays and handhelds to wall displays to projection systems, all sizes and approaches are of interest. All areas of display technology applications from point-of-sale information screens to advanced social-media enablers belong in this category. In particular, display-related technologies might have non-display applications, some of which to date have been revolutionary. What new applications are enabled for technologies that stem from display industry?

## EMISSIVE DISPLAYS

### Quantum-Dot Materials

Quantum dots are nanoscale semiconductor materials that exhibit optoelectronic properties that are intermediate between those of bulk semiconductors and those of discrete molecules. They are highly engineered materials whose frequency of emission can be very-narrow-band and precisely tuned by changing the particle size, shape, and material. Tunable light emission occurs when either electricity [electroluminescence (EL)] or light [photoluminescence (PL)] is applied to them. Currently they are used commercially as color-conversion materials in backlight units of LCD TVs and monitors, but significant development effort is underway to enable color conversion at the pixel level for LCDs, OLEDs, micro-LEDs, and microdisplays. Their use in creating direct-view emissive displays (QDEL) where the emissive electroluminescent layer is a film of quantum dots that emit light in response to an electric current holds great promise for the future of the display industry. Papers concerning the science and technology of quantum-dot materials for all display applications are solicited.

### Quantum-Dot Applications

Quantum-dot down-conversion is currently implemented in LCD backlights and is beneficially impacting LCD performance. Research and development into the photoluminescent down-conversion or down-shifting applications of quantum dots, their benefits, unique implementations, packaging methods, optics, and environmental performance are accelerating. Papers concerning the implantation of quantum-dot materials in display devices are solicited.

### Quantum-Dot Cathodoluminescence (CL) and Electroluminescence (EL)

With the market success of quantum dots as down-conversion materials for LCDs, their application in future electroluminescent emissive displays (QLEDs) has seen a resurgence of interest within the research community. Papers concerning QLED-device-stack innovations, QD material patterning (ink-jet printing, contact printing, etc.), QLED-degradation mechanism investigation, and QLED hybridization with organic emitters for emissive displays are solicited.

## Perovskite Electronics

Perovskites, including organic–inorganic and all-inorganic perovskites have recently attracted intense interest owing to their good fluorescent and electroluminescent properties, such as narrow emission linewidth and tunable emission wavelength. The electronic properties can be manipulated by molecular engineering, thus making them valuable as an additional set of materials for display applications. Perovskites have been employed in light-emitting devices (PeLEDs) in an analogous manner to that of OLEDs. Papers concerning perovskite fluorescence, electroluminescence, PeLEDs, and any other display-related perovskite devices are solicited.

## Phosphors

Plasma displays, inorganic EL displays, LEDs, phosphor-based laser displays and lighting, FEDs, and CRTs are all light-emitting devices that use phosphors. Research and development of phosphor materials for these devices are expected to improve the light-generation efficiency, color purity, color range, longevity, and reliability of such devices. Papers concerning the science and technology of phosphors for these devices are solicited.

## Plasma, Field-Emission, and Inorganic EL Displays

Plasma displays, field-emission displays, and inorganic electroluminescent displays are all mature display technologies that have had varying degrees of market success and remain of interest to the research and development community. Papers concerning the power consumption, panel design, image quality, new driving methods, electronics design, manufacturing, novel applications, or material innovations within any of these display modes are solicited.

## Micro-LEDs

Micro-sized LEDs (including devices fabricated using both monolithic and hybrid approaches) have numerous possible applications including (i) high brightness microdisplays for AR applications, (ii) extremely high-resolution glasses-free 3D images with holographic capability, and (iii) large-sized displays with very low power consumption. Papers that describe the science and technology of micro-LED devices, electronic control, materials, fabrication, and characterization for display and non-display applications are solicited.

## e-PAPER AND FLEXIBLE DISPLAYS

### Electronic Paper

Electronic paper (e-Paper) combines the benefits of ink on paper with the rewritability of an information display. This category includes both rigid and flexible displays employing electrophoretic, electrowetting, flexible Ch-LCDs, MEMS, and other novel reflective displays. Papers submitted in this category may cover topics such as the characterization and measurement of e-Paper display performance or integration issues specific to e-Paper displays. Backplane electronics, integrated drive electronics, drivers, applications, and user interfaces for e-Paper displays are included in the topic.

### Flexible OLED and Other Emissive Materials, Displays, and Devices

Flexible OLEDs and other emissive materials such as quantum dots continue to be of high interest to the display community for more robust, rollable, or even foldable device form factors. Papers describing novel techniques enabling flexible emissive displays, flexible high-efficiency and robust materials, flexible encapsulation/passivation techniques and materials, protective surface materials, manufacturing methods suitable for flexible OLEDs, and stable passive- and active-matrix flexible black and white, gray-scale, and full-color displays are particularly welcome.

## EPD, MEMS, and Other Non-Emissive Flexible Displays and Devices

Liquid crystals are the most familiar non-emissive displays. MEMS technology is always important as micromirrors in projection displays, but novel emissive and non-emissive applications for direct-view mobile displays, e-paper, and signage are also under active development. Papers are sought on MEMS, electrophoresis, electrowetting, electrochromism, and other non-emissive technologies, as well as their associated materials for flexible applications.

## Flexible Sensors and Wearable Displays

Flexible, stretchable, thin, light, and robust displays offer the potential to integrate interfaces into objects in the environment and to wear on the body. While touch has quickly become a preferred method for interaction with displays, other sensors and input modes can enhance the user experience with a more intuitive, seamless, and data-rich interaction. Papers are sought on all manner of flexible or wearable touch and other environmental or bio-sensors, electronic-skin sensors, flexible display interfaces, and novel applications or uses for flexible electronics.

## Flexible Display Materials Including Substrates, Films, Adhesives, and Barriers

Material developments to support the efforts of flexible-display development are appropriate topics for these sessions. These topics include new substrate materials, properties, and handling methods; flexible barriers, improvements in consumable materials such as adhesives, polarizers (including film and coated polymer types), and optical-enhancement films. Assembly, module, and interconnect materials such as adhesives, desiccants, and ACF are included. Papers dealing with flexible films, roll-to-roll materials and processes, and ink-jet printing are solicited.

## Organic and Inorganic Solution-Based TFTs and Device Performance

Organic and other printable TFTs show promise as a potential low-cost TFT alternative to Si-based TFTs for a range of display applications, and particularly for flexible-display applications. Active-matrix displays produced with low-temperature processes on flexible substrates can provide increased durability, better shock resistance, decreased weight and thickness, and unique product shapes. To ensure success, these devices must show sufficient mobility, low-leakage currents, acceptable on/off ratio, uniformity, and especially good stability, both environmentally and under bias-stress conditions. Papers relating to printed electronics and integration with display devices are sought including the fabrication and performance of low-temperature a-Si:H, poly-Si, oxide-based, organic, or new array processes, flexible substrate material issues such as chemical attack inertness or dimensional tolerance control due to distortion, compaction and/or warping, substrate material, and processing cost. Contributions are also sought on novel pixel designs, process, high integration, and addressing methods.

## Integration, Packaging, Testing, and Reliability for e-Paper and Flexible Displays

As new flexible display technology is developed for e-paper, OLEDs, and novel display technologies, key aspects of their commercialization will be the integration and packaging of these displays, and the reliability to both environment and mechanical stressing. Papers are sought that address these issues including package and driver designs, testing results, tools, procedures, and materials.

## Flexible-Display and e-Paper Manufacture of and Equipment for Printed Electronics

As new technologies are maturing, novel equipment and processing methods are being developed to take advantage of new materials and substrates. This topic includes low-temperature processing of

materials; roll-to-roll manufacturing, printed, and solution-based processing of electronic materials. Papers discussing advances in tools, materials, devices, and displays are sought.

### **Applications and Ergonomics of Integrated Flexible Electronics**

The integration of displays with other functional flexible electronic components is a key manufacturing challenge for the industry, but often essential to realize new applications for integrated or wearable electronics. The ergonomics of such systems is also a key element for market acceptance. Papers are sought covering comprehensive functional systems produced on flexible substrates including display devices, memories, sensors, batteries, solid-state lighting, photovoltaic or other technologies used in conjunction with an electronic display. Materials, process technology, assembly, functionality, and simulation are welcome. Criteria, demonstrations, or new uses related to the ergonomics of such devices are also sought.

### **Flexible and Stretchable Hybrid Electronics**

Hybrid electronics defines a device or system that contains both flexible/stretchable elements and rigid components and shows excellent flexibility and stretchability, which are key features enabling future wearable devices, such as flexible displays, conformal E-skin, flexible sensors, flexible energy harvester/generator, electronic-eye camera, etc. Papers are sought covering the advancement of performances, theory of mechanics, material issues, device design, manufacturing or fabrication process, and prototype demonstration.

### **Materials and Devices for Novel Mechanical UI/UX Technique**

The mechanical UI/UX technique will become very important as various flexible display panels or modules emerge in the marketplace. Flexing- or bending-based interactive interfaces will add more functions and novel input/output features to the flexible display. Papers on novel materials, process and devices for strain/bending sensor arrays, force-touch or pressure sensor arrays, flexible/stretchable interconnection, or substrate platforms are sought.

### **Materials and Devices for Textile/Fiber Displays and Electronics**

Integrating electronic devices with clothing is going to open many new opportunities for consumer electronics. Prototyping flexible displays and electronic systems on textile substrates or into the fiber-based platform are beginning to be widely demonstrated. Papers are sought that cover fundamental issues of substrate handling and processes, thin-film deposition and patterning techniques, novel device structures, and materials/processes for device fabrication. In addition, papers on prototyping electronic systems that contain sensors, photovoltaic devices, energy harvesters, and generators, actuators, locating devices, or displays are sought.

## **LIGHTING**

### **Material and Device Development for Solid-State Lighting**

Papers describing notable developments in LED and OLED lighting sources aimed at improvement in device performance and cost reduction, reliability of lighting sources, research on emitting materials for improved efficiency and lifetime, and development of down-conversion materials. Also, trends and technologies for future lighting solutions and alternative light sources.

### **Manufacture of Lighting**

The topic covers the development of flexible LED and OLED lighting systems, advancements in the processes and materials required for manufacturing on flexible substrates, and the design of novel luminaires and form factors and their applications. Development of critical components in solid-state lighting, such as light modules, improved and cost-effective light extraction, substrates, optics, drivers and ICs, thermal management, sensors, and detectors will also be covered.

### **Visual and Non-Visual Effects of Lighting**

The focus of this topic is the quality of light, including color rendering, flicker, and glare for indoor and outdoor applications.

### **Biological and Psychological Impact of Lighting and Related Health Effects**

This topic includes the visual neuroscience behind lighting or display designs, the visualization of lighting on displays, integrated lighting needs and strategies for health-care applications, and understanding and optimizing the productivity of horticulture through the impact of lighting.

### **Color-Changing and/or CCT-Tunable Luminaires**

This topic includes the strategy and algorithm for color-changing and CCT-tuning applications or case studies of such luminaires, control systems for color tunable products, and photometric testing of color-tunable luminaires.

## **LIQUID-CRYSTAL DISPLAYS**

### **Flexible and Conformable Displays**

This topic covers all aspects of flexible-display technologies, including flexible Ch-LCDs, new flexible LCDs, and novel flexible reflective displays. The goal is to capture new display modes and display materials and components related to flexible-display technologies. Papers on advances directed at the development of substrates, novel fabrication techniques, drive techniques, electro-optical effects, manufacturing, and applications for flexible-display technology are sought. Material developments to support the efforts of flexible-display development are also welcome.

### **Fast-Response and Color-Sequential Displays**

A field-sequential-color (FSC) display does not require spatial color filters. As a result, its optical efficiency and resolution density are tripled. High optical efficiency lowers the power consumption, while high-resolution density improves the image fidelity. However, to achieve FSC without noticeable color breakup, the LC response time should be fast (ideally <1 msec) in order to enable high-frame-rate operation. Papers on new LC materials, operation modes, backlight sources, and driving methods for achieving fast response time while mitigating color breakup are encouraged.

### **High-Dynamic-Range and High Ambient-Contrast LCDs**

High dynamic range offers supreme image quality, including high peak brightness, true black state, high ambient contrast ratio, and at least 10-bit gray levels. For LCDs, high brightness can be obtained by boosting the backlight, and high dynamic contrast can be achieved by local dimming, although the dimming accuracy depends on the segments of LED backlight and algorithm optimization. High ambient contrast is particularly important for mobile displays, where sunlight readability is a critical issue. This session covers all the technical aspects related to high dynamic range and high ambient contrast ratio.



## Wide-Color-Gamut and Quantum-Dot Enhanced LCDs

Wide color gamut (WCG) represents a more complete reproduction of colors seen with our eyes in real-world scenes, which is currently one of the most exciting display topics. The very recent developments in color-enhanced LCDs using quantum dots (QDs) or dyes have been carried out to expand the range of colors. Especially, QDs which yield highly saturated color emissions for purer primaries can create more colorful and lifelike images. This session will cover all aspects of technologies for WCG and QD-enhanced LCDs. Papers addressing color-converting materials, color filters, backlights, optical films, driving schemes, human factors, and all studies related to WCG and QDs are encouraged.

## LC-Based Spatial Light Modulators and Optical Elements

Liquid crystals have also been widely used in many photonic applications, such as spatial light modulators, adaptive lenses, diffractive optics, lasers, smart windows, tunable filters, and microwave and terahertz phase shifters. In particular, the fast phase modulation and/or the high diffraction efficiency for holographic applications are in great demand. Original papers addressing advanced materials, new phenomena, device physics, and new applications that may relate to new display applications are all encouraged.

## LC Alignment and New LC Materials

LC alignment is essential in the operation of LCDs. New techniques, especially photoalignment, have been deployed recently for manufacturing. Papers covering new LC alignment techniques that improve LCD performance, reduce cost, and improve production yield, as well as allowing the realization of novel LCDs and optical elements, are solicited.

## Use of LC Technologies in Biomedical Applications

The combination of the advances in the fields of liquid crystals and biomedical engineering results in remarkable interdisciplinary research having a significant impact in diagnostics and treatment options. Papers covering the latest advances being made in displays, spectroscopy, sensors and diagnostics, bio-mimicking, actuators and lasers with regards to liquid crystalline materials as well as biomedicine are solicited.

## ORGANIC LIGHT-EMITTING-DIODE DISPLAYS

### New AMOLED Display Pixels and Backplanes

OLEDs have been a focal point in the display industry because of their superb image quality and slim form factor. AMOLED displays have seen an explosion in their use in smart phones to TVs. However, progress is still being sought in high-volume production: differential aging, image burning, power consumption, backplane consistency, manufacturability, and cost. Progress is being made on all of these fronts and on improving maximum brightness for daylight readability. Papers related to AMOLED display technologies, such as pixel structure, circuitry, and driving scheme, with an emphasis on its backplane advances, are solicited.

### OLED TV, Mobile, and Large-Area Applications

OLED-based displays have several unique attributes that continue to drive their growth in portable video-capable devices such as tablets and smartphones and increase the demand for television applications. Papers are sought that describe unique OLED display demonstrations that highlight the distinctive attributes of OLED architectures. In particular, papers are sought for OLED-based displays with unique attributes that include transparent OLEDs, high-resolution displays and, large-area displays for TV and 3D TV applications. Papers covering materials (small molecule and polymer), devices, patterning, and unique drive schemes leading to television applications will be considered.

## Novel OLED Materials and Architectures Enabling Emerging OLED Displays

Unique solid-state low-process temperatures are enabling features for full-color flexible emissive displays. In addition, the OLED ultra-fast response times contribute to vibrant 3D displays. Papers describing enabling device architectures and robust thin-film encapsulation that lead to stable passive- and active-matrix flexible full-color displays are particularly welcome. Papers describing novel OLED architectures that contribute to 3D displays will be an important contribution to OLED sessions. Such device architectures may include top and bottom emitters that uniquely enable OLEDs on flexible substrates.

## Active- and Passive-Matrix OLED Display Technology

Papers that discuss the progress and challenges for OLED display performance and manufacturing issues generally applied to active- and passive-matrix displays are of particular interest.

## Emerging OLED Displays

Papers in the area of OLED devices with rare and exceptional characteristics such as polarized emission and transparency are sought. Papers addressing novel and robust materials and fabrication techniques are especially welcome. Such paper topics include large-area signage and unique passive addressing.

## OLED Device and Materials Fundamentals

Papers in the area of vacuum-thermal-evaporation (VTE) OLED and polymer-OLED materials and device architectures with state-of-the-art performance in terms of color chromaticity, high power efficiency, and long operational lifetime at display-level luminance are sought. Papers are solicited for novel techniques which enhance high out-coupling efficiency of OLEDs. These areas include microcavities, index matching, optics, simulation, and design of OLED microdisplays. Of particular interest are deep-blue and white devices with high efficiency, color, and long lifetime.

## Injection and Transport Mechanisms, Molecular Engineering, and Device Structure

The continued improvements of organic materials via molecular engineering and fundamental studies of the dynamics of charge carriers and excited states are important to the OLED industry. Papers treating injection, charge generation, transport, and recombination phenomena in individual materials, interfaces, and complete OLED devices are sought, including modeling and computational chemistry techniques. Of particular interest are contributions that apply to the understanding of device and material fundamentals to design OLEDs with high efficiency, low voltage, long lifetime, and saturated emission colors.

## OLED Stability and Degradation Mechanisms

Lifetime of OLED devices is one of the most important factors enabling their display and lighting applications. Papers providing insight into degradation mechanisms and describing novel materials and device architectures to substantially increase lifetimes and suppress differential aging and image sticking are solicited.

## OLED Applications for Lighting

High-efficiency, high-CRI, and robust white OLEDs for RGBW displays, color-filter approaches, and solid-state lighting, are of special interest to the display and energy-conscious communities. Papers describing novel materials and device architectures that are capable of producing efficient and stable white emissions are particularly welcome.

## OLED Manufacturing

Novel full-color OLED fabrication and patterning techniques that are capable of producing high-resolution displays are of high interest for the industry. Papers dealing with recent advancements in

areas of thermal deposition, ink-jet printing, nozzle printing, other novel small-molecule and polymer deposition techniques as well as development of solution-processed OLED materials and devices are sought. Particularly, approaches to obtain multi-layered devices from solution are highly welcome.

### **OLED Systems Packaging, Integration, and Cost Reduction**

Encapsulation is critical to ensure long operational lifetime of OLED displays. Papers describing packaging and thin-film encapsulation advancements for novel designs such as top-emitting and flexible displays are of particular interest to the community.

## **TOUCH AND INTERACTIVE DISPLAYS**

### **Touch Systems, Controllers, Sensor Design, and Signal Processing Algorithms**

Papers in this session should describe novel state-of-the-art techniques for sensing multi-touch on a display, with quantitative characterization and discussion of their performance. Topics include:

- Touch controller electronics, AFEs, and driving schemes
- Multi-touch sensor design, stackups, and geometries (*e.g.*, diamonds, snowflakes, bars and stripes, telephone poles, *etc.*), including field studies
- Novel In-cell and On-cell systems
- Novel OGS (one glass solution) systems
- Signal and gesture processing algorithms, including palm rejection
- Processing architecture (host vs. ASIC side)
- Integration with display electronics
- Approaches to reducing latency

### **Novel Interactive Displays**

This session solicits novel papers on interactivity that is fundamentally associated with a display. Examples include:

- Simultaneous Touch + Pen systems (both passive and active)
- Hover sensing (finger and/or touch)
- Pressure/force/strain sensing
- Integrated biometric sensing (such as fingerprint scanning)
- Other sensors integrated into the display substrate

We will not accept papers that describe user input sensing systems merely running alongside a display.

### **Materials and Process Technologies**

The recent rapid evolution of touch-screen technology can be partly attributed to the development of improved materials, processes, and equipment for touch-panel fabrication. Papers are solicited in all aspects of novel material or process technologies for touch screens with improved performance or lower cost.

#### **Materials include:**

- Substrates (including novel glasses, flexible films)
- Functional coatings (*e.g.*, anti-scratch, fingerprint resistant)
- Transparent conductors (ITO alternatives, carbon, nanowires, metal-mesh, *etc.*)

#### **Processes include:**

- New fabrication processes for touch panels
- Patterning methods for touch-panel materials
- Interconnect processes to the external electronics
- Integration methods with the display (direct lamination/bonding to the display or to the cover glass or as an even more integral part of the display)

### **Human Factors and Touch-Performance Evaluation Methodology and Standardization**

Touch-screen technology is now being widely used in almost all applications of displays; this has introduced us to many new touch

devices. There are more than 10 touch technologies, more than 100 touch manufacturers, and many thousands of touch products. Accordingly, touch-performance evaluation and standardization has become much more important. Papers are solicited in all aspects of novel evaluation and/or standardization methodology of touch performance and characteristics. Aspects can be considered at the level of the touch panel, the touch module (panel plus controller), and/or finished products that use touch (mobile phones, tablets, notebook PCs, AiOs, IWBs, *etc.*). The evaluation methodology can include evaluation criteria, measurement systems, specifications such as accuracy, response, sensitivity, and internal/external noise immunity, new evaluation methodology for matching actual touch performance, and technology to standardize or quantify the evaluation and measurement methods used by each manufacturer. Methodology of subtle optical characteristics particularly found frequently in touch systems are encouraged. Papers in this session should also explore touch systems from the human perspective; for example, how human factors drive touch-screen specifications, appropriate gestures for different form factors, and user studies in an application context.

## **AUTOMOTIVE / VEHICULAR DISPLAYS AND HMI TECHNOLOGIES**

Papers for this topic shall deal with all aspects of automotive and vehicle displays and related HMI issues, including market aspects, display and lighting technologies, head-up displays, application issues with vehicular displays, and advanced technologies for displays, touch screens, and gestures in vehicles as well as the user experience. Contributions in the following areas are solicited:

### Displays

- **Display and Lighting Technologies Applicable to Automotive/Vehicular Applications**
- **Advanced Technologies for Displays and Touch Screens for Automotive Use**
- **Usage of and Trends in Automotive Displays, Interfaces, and Applications**
- **Displays for Driver-Assistance Systems (Navigation, Collision Warning, *etc.*)**
- **Passenger Infotainment and Projection Displays**
- **Head-Up Displays (HUDs), Including Holographic, Augmented Reality, Night-Vision Systems/Components**
- **Display Measurements for Automotive Displays**
- **Flexible, Curved, and High-Resolution (Low Power, Sunlight Readable) Displays**
- **Touch-Input Devices (In-Cell, Water Resistant, Chemical Resistant) for Automotive Displays**
- **Motorbike Displays and Applications**
- **Application Issues with Vehicular Displays and Lighting**
- **Optical Components for Automotive Applications**
- **Display Materials Optimized for Automotive Applications**
- **LEDs, OLEDs for Lighting, Signaling, *etc.***
- **Display Legibility, Visual Performance, Driver Distraction, *etc.***
- **Optical, Mechanical, Electrical, Thermal Performance**
- **Modeling and Simulation**
- **Avionic Displays and Applications (including HMD, HUD, and Interaction Means)**
- **Touch-Screen and Haptic Technologies for Automotive Displays**
- **Methods for Display Power Reduction**

### HMI Technologies

- Human-to-Machine Interface (HMI) System Solutions
- HMI and User Experience (UX) for Driver Assistance Systems and Automated Driving
- Multi-Modal Input and Output
- Driver/User Interfaces (User-Centric Design, Devices, Human Factors, etc.)
- Passenger Entertainment and User Experience
- Driver Interfaces and Interaction with More Than One Display
- Personalized User Interfaces
- Methods and Tools for Automotive User-Interfaces and Simulations
- Automotive User Experience (UX), Trends, Methods, Evaluation
- Application Issues with Automotive HMIs
- Customer Acceptance and Feedback on Different Technology Displays and Interfaces
- Regulation and Trends Related to In-Vehicle Interfaces