Flat Panel Displays
Room 313 - Session FP-MoA

Flexible Displays
Moderator: R.M. Wallace, University of North Texas

2:40pm **FP-MoA3 Microencapsulated Electrophoretic Particle Systems for Flexible Electronic Display Applications**, ***P.S. Drzaic***, E Ink Corporation **INVITED**

The proliferation of portable electronic devices has caused increased interest in new display technologies that overcome the many limitations in traditional flat panel displays. In particular, most current display technologies, particularly those based on fluids, require one or more sheets of glass in the display construction. One strategy for making fluid-based display technologies compatible with film substrates is to create a dispersion of a fluid in a polymer matrix. Microencapsulated electrophoretic displays@footnote 1@ ("electronic ink") offer a unique and interesting set of properties: high reflectivity and contrast, a paperlike appearance, low power consumption, and compatibility with flexible substrates. In electronic ink displays, microcapsules serve to contain a colored, nonaqueous fluid containing electrophoretically-mobile particles. An electric field is used to move particles to either the front or back of the display, so that a viewer either sees the particles or the colored oil. Depending on the surface chemistry of the colloid and polymer, the particles can remain in place long after the electric field is removed. This property gives the display image an inherent persistence of the without further power consumption. Here, I will describe the optical and electrical characteristics of these microencapsulated display materials based on rutile titanium dioxide colloidal particles. Electronic ink devices are also highly compatible with microelectronic circuits, either based on traditional silicon devices or on novel semiconducting organic materials, and I will also discuss recent progress in this integration. @FootnoteText@ @footnote 1@B. Comiskey, J.D. Albert, H. Yoshizawa, J. Jacobson, Nature, 394, 253 (1998).

3:20pm **FP-MoA5 Low Temperature Deposition and Characterization of Polycrystalline Si Films**, ***S.I. Shah***, *K. Xu, D. Guerin,* University of Delaware

Polycrystalline silicon (poly-Si) thin films were deposited by dc magnetron sputtering at temperatures as low as 150°C on poly(ethyleneterephthalate) (PET) and glass cover slips. Film growth was studied as a function of the partial pressures of argon, hydrogen and krypton and different substrate bias conditions. X-ray diffraction analyses showed that films grown with a gas ratio (Ar: Kr: H@sub2@ = 17:2:1) were polycrystalline. The crystallinity of the films was also dependent on the applied substrate bias. Both the dc bias and the partial pressure of Kr enhanced the adatom mobilities leading to a crystalline film formation. The substrate bias, however, had a critical limit beyond which the crystallinity of the films again decreased. X-ray photoelectron spectroscopy (XPS) depth profiles indicated intermixing at the film-substrate interface. The intermixing was strongly dependent on the ion bombardment due to the substrate bias. We will present TRIM models to explain the effects of both the H and Kr addition to the sputtering gas.

3:40pm **FP-MoA6 Ultra-Barriers of ITO with Low Sheet Resistance**, ***C.I. Bright***, *M.A. Roehrig,* Presstek, Inc.

The drive to develop Flat Panel Displays (FPD) on flexible substrates has been impeded by the permeability of plastic substrates to water vapor and oxygen which degrade the display medium or electrode materials. Recently, dielectric and ITO thin films barrier layers, separated by polymer layers, vacuum deposited on plastic sheets have demonstrated oxygen and water vapor transmission rates at or below the measurement limits of commercial instrumentation (0.005 cc/m@super 2@day and 0.005 gm/m@super 2@day). We report for the first time, ITO ultra-barriers with performance at or below this measurement limit, produced by vacuum roll to roll deposition. These ITO ultra-barriers, sputter deposited on plastic film substrates, have a typical visible transmittance of > 80% and a sheet resistance of < 20 ohms/square. Details of the deposition process, multilayer construction and measured performance are reported.

4:00pm **FP-MoA7 The Incorporation of High Performance Silicon-based Devices on Flexible Substrates using Self-Orienting Fluidic Transport**, ***R. Stewart***, Alien Technology **INVITED**

PLEASE SEND US AN ABSTRACT. Thank you.

4:40pm **FP-MoA9 Deposition of Silicon Nitride on a Polymer Substrate by Plasma Enhanced Chemical Vapor Deposition**, ***D. Guerin***, *S.I. Shah,* University of Delaware

Silicon nitride thin films were deposited on poly(ethyleneterephthalate) (PET) by plasma-enhanced chemical-vapor deposition (PECVD) in a capacitively coupled reactor. The process of film growth was examined using X-ray photoelectron spectroscopy (XPS) and atomic force microscopy (AFM). Films were grown for varying lengths of time and transferred under vacuum into an attached XPS system. AFM measurements were performed ex situ. Results indicated that the film growth process was highly dependent on the power density of the plasma. The higher the power density, the longer it took to achieve a pure silicon nitride film. With higher power plasma, the etching of the polymer substrate was observed in the initial stages of the process. This provided carbon and oxygen atoms which get incorporated into the film. Power density also affects the morphology of the thin films. In lower energy plasmas, there is less chemical interaction between the substrate and deposited film. High resolution XPS measurements of the C 1s region indicated that the main effect of the plasma on the substrate was to modify the surface such that an amorphous polymer interface was created between the bi-axial crystalline polymer and the amorphous inorganic film. The little carbon that did get incorporated into the film was C-H bound. Above some critical power density a distinct carbon peak appeared indicating that carbon from the substrate is being incorporated into the film through either Si-C or N-C bonds. AFM measurements revealed that higher energy deposition led to higher nucleation density and surface coverage. XPS measurements, however, continued to show the C 1s peak even after 40 sec. of deposition. In samples deposited at low energy, the C 1s peak disappeared after only 30 sec. of deposition. Based on these observations, we will present a model of the initial stages of silicon nitride growth on PET.

5:00pm **FP-MoA10 Mechanical Properties and Thin Film Transistor Performance for Flexible Displays**, ***S. Wagner***, *H. Gleskova, Z. Suo,* Princeton University

Flexible displays have become of considerable near-term interest for portable computing and communication devices, because flexibility is equated with ruggedness and light weight. In these applications the displays may be flexed only a few times before they become permanently embedded, often in nonplanar configurations. Longer-term applications include products that will be flexed throughout their entire lives, for example, rollable displays and electronic books. While in some instances display components may be deformed plastically during fabrication, one may seek to exclude plastic deformation during use. Elastic deformation may be induced by bending, coiling, twisting, or stretching. We will focus on the best-understood case of elastic deformation by bending. Three question arise when a thin film transistor (TFT) is subjected to bending: (i) How much bending can a TFT tolerate? (ii) What happens in the TFT during bending? (iii) How does fatigue from repeated bending manifest itself? We have found that: (a) We are beginning to understand elastic deformation of TFT/substrate structures, but still need to understand plastic deformation; (b) Amorphous silicon TFTs are more sensitive to tensile than to compressive strain, and surface passivation may make them more resistant against tensile failure; (c) The mechanical properties of substrate and encapsulation should be tuned such that the circuit comes to lie in the neutral plane.

Flat Panel Displays
Room 313 - Session FP-TuM

Luminescent Materials
Moderator: B.E. Gnade, University of North Texas

8:20am **FP-TuM1 Cross-sectional TEM Investigation of the Dead Layer of ZnS:Ag,Al Phosphors in Field Emission Displays**, ***K. Kajiwara,*** Sony Corporation, Japan

The dead surface layer of blue-emitting ZnS:Ag,Al phosphor was investigated by means of cross-sectional transmission electron microscopy for the first time. It was found that the electron radiation-induced damage at 6 keV excitation gives rise to (i) the decomposition of ZnS and the evolution of sulfur at the topmost surface, and (ii) the nucleation and multiplication of lattice defects, for example vacancy clusters and dislocations, at the electron penetration layer of approximately 300 nm. It was estimated that the decompositon rate of ZnS and the nucleation rate of defects depend on the crystallinity and surface roughness of the ZnS host crystal. Based on these evidences, necessary specifications of ZnS:Ag,Al phosphor for the long lifetime of field emission display are to be discussed in this preliminary work.

8:40am **FP-TuM2 Enhanced Activator Interactions During Low Electron Energy Cathodoluminescence**, ***C.H. Seager,*** *D.R. Tallant,* Sandia National Laboratories **INVITED**

We have measured the time decay of spectrally-resolved, pulsed cathodoluminescence (CL) and photoluminescence (PL) in several phosphors activated by rare earth and transition metal impurities; These included Y@sub 2@O@sub 3@:Eu, Y@sub 2@SiO@sub 5@:Tb, and Zn@sub 2@SiO@sub 4@:Mn; typical activator concentrations ranged from ~ 0.25 to 10%. The CL decay curves are always non-linear on a log-linear plot - i.e. they deviate from first order decay kinetics. These deviations are always more pronounced at short times and larger activator concentrations and are largest at low beam energies where the decay rates are noticeably faster. PL decay is always slower than that seen for CL, but these differences disappear after most of the excited species have decayed. We have also measured the dependence of steady state CL efficiency on beam energy. We find that larger activator concentrations accelerate the drop in CL efficiency seen at low beam energies. These effects are largest for the activators which interact more strongly with the host lattice. While activator-activator interactions are known to limit PL and CL efficiency in most phosphors, the present data suggest that a more insidious version of this mechanism is partly responsible for poor CL efficiency at low beam energies. This "enhanced" concentration quenching is due to the interaction of nearby excited activators;these interactions can lead to non-radiative activator decay, hence lower steady state CL efficiency. Excited state "clustering" appears to enhance these interactions, and this may be caused by the large energy loss rate of low energy primary electrons. In support of this idea, we find that PL decays obtained at high laser pulse energies replicate the non-linear decays seen in the CL data. This work was supported by DARPA. Sandia National Laboratories is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract #DE-AC04-94AL85000.

9:20am **FP-TuM4 Growth and Characterization of Pulsed Laser Deposited Zn2GeO4:Mn Green Thin Film Phosphors**, ***T. Feng,*** *P.H. Holloway, D. Kumar, M. Davidson,* University of Florida*; J.M. Fitz-Gerald, H. Kim,* Naval Research Laboratory*; D.P. Norton, Y.E. Lee,* Oak Ridge National Laboratory

Pulsed laser deposition of Zn2GeO4:Mn oxide thin films on glass/ITO/ATO and Al2O3/Au/PZT substrates, which are potentially used for electroluminescent displays, has been investigated. A stoichiometric target Zn2GeO4:Mn was obtained by sintering a mixture of ZnO, GeO2 and MnO2 powder in air at 1020oC for 24 hrs. A green photoluminescence peak was obtained from the target at a wavelength of 540nm. Films were pulsed laser deposited on glass/ITO/ATO and Al2O3/Au/PZT substrate at an O2 pressure of 150~200 mTorr and a laser density of 0.8~1.6J/cm2. All deposited films were Zn-deficient in contrast to the stoichiometric target ratio for Zn/Ge of 2. The films deposited at 250oC on glass/ITO/ATO showed a Zn/Ge ratio of 1.02, while films deposited at 800oC were more Zn-deficient with a ratio of 0.82. The Zn2GeO4:Mn films deposited at 250oC on glass/ITO/ATO were amorphous, but recrystallized upon rapid thermal annealing at 800oC in Ar for 1 min. Photoluminescence with an intensity of 46 cd/m2 at a peak wavelength of 536nm was obtained from a 300nm film deposited on Al2O3/Au/PZT at 250oC followed by post-annealing at 750oC in air for 1 hr. Photoluminescence of 11 cd/m2 was obtained from a film deposited on glass/ITO/ATO followed by rapid thermal annealing at 800oC in Ar for 1 min. A surface particulate density of 2.42x105/cm2 was observed in the film deposited on glass/ITO/ATO substrate at a temperature of 250oC, O2 ambient pressure of 200 mTorr and laser density of 0.8mJ/cm2. Films deposited at 800oC showed a large density of pinholes, in addition to surface particulates. Annealing in O2 ambient resulted in a better PL intensity compared to annealing in air or Ar ambient.

9:40am **FP-TuM5 Energy Loss Mechanisms in Pulsed Laser Coated Cathodoluminescent Phosphors**, ***W.J. Thomes,*** *P.H. Holloway,* University of Florida*; C.H. Seager, D.R. Tallant,* Sandia National Laboratories

Coatings of MgO and Al@sub 2@O@sub 3@ were pulsed laser deposited onto sedimented screens of Y@sub2@O@sub 3@:Eu and Y@sub 2@SiO@sub 5@:Tb to study energy loss mechanisms in the coatings and to predict their impact on cathodoluminescence (CL). The thickness of the pulsed laser deposited coatings, characterized by ellipsometry, TEM and AES sputter profiles, were varied from 75 to 500 Angstroms by changing the deposition time and oxygen background pressure. A Si shadow mask covered half of the sedimented powder during deposition to allow comparison of coated and uncoated powder. DC and pulsed cathodoluminescence data were collected using an Ocean Optics fiber optic spectrometer or a modified Kimball Physics electron gun, respectively. Light was collected using fiber optics connected to a photomultiplier tube or a CCD detector. The beam energies were varied from 0.8 to 4 keV, while the current was kept constant at 0.16 μA/cm@super 2@. The coating thickness on particles was modeled by assuming a uniform flux depositing over a spherical powder surface. Spatially resolved electron energy loss was calculated to predict the CL intensity versus beam energy and incident angle relative to the local surface normal. The predictions of the CL intensity versus incidence angle, coating thickness, and primary beam energy agreed well with experimental data. The consequences of these data relative to phosphor degradation and low voltage efficiency will be discussed.

10:00am **FP-TuM6 Effect of He/Ar Sputtering Gas Mixture on the Brightness of RF Magnetron-Sputtered ZnS:TbOF for Alternating Current Electroluminescent Displays**, ***J.P. Kim,*** *M. Davidson, D. Moorehead, P.H. Holloway,* University of Florida

ZnS:TbOF has shown promise as a green electroluminescent phosphor. We have studied the effects of He/Ar mixture as ambient gas on the brightness of ZnS:TbOF thin film electroluminescent devices. ZnS:TbOF phosphor films were planar magnetron sputter deposited from consolidated powder targets of ZnS:TbOF (1.5 mol %) at 120W. All films were deposited at a substrate temperature of 160°C and total pressure of He/Ar gas was kept at 20mTorr. Helium gas ratio was changed from 0% to 70%. Top insulator layer was planar magnetron sputter deposited from consolidated powder targets of BaTa@sub 2@O@sub 6@. The sputtering deposition rate of ZnS:TbOF was in the range of 84Å/min - 113Å/min and was not changed significantly by increasing the He/Ar ratio. He/Ar gas mixture up to 50% He don't result in any significant change of the brightness (B@sub 40@@super half@) of half stack structures (bottom dielectric layer and top Al dot contact directly on the ZnS:TbOF) for either as-deposited or annealed films (500 °C,60 min). At a higher helium ratio (> 60%), the B@sub 40@@super half@ decreased for both as-deposited and annealed films (500 °C, 60 min). Surface roughness was less for >60% He, as measured by Atomic Force Microscopy (AFM). Full Width of Half Maximum (FWHM) from X-ray diffraction showed increased crystallinity of deposited film > 60% He. Films deposited at > 60% He exhibited higher dielectric constants. Therefore, the brightness decrease in high helium is attributed to reduced roughness and increased dielectric constant of the phosphor layer. This work was supported by DARPA Grant MDA 972-932-1-0030 through the Phosphor Technology Center of Excellence.

10:20am **FP-TuM7 Eu@super +3@ and Cr@super +3@ Doping for Red Cathodoluminescence in ZnGa@sub 2@O@sub 4@**, ***J.J. Peterson,*** Advanced Vision Technologies, Inc.*; P.D. Rack,* Rochester Institute of Technology*; M.D. Potter,* Advanced Vision Technologies, Inc.

Cathodoluminescence (CL) emission spectra and photoluminescence (PL) excitation spectra were used to evaluate Eu@super +3@ and Cr@super +3@ as activators for red luminescence in ZnGa@sub 2@O@sub 4@. In the Eu@super +3@ doped ZnGa@sub 2@O@sub 4@ materials blue host emission was observed at high current densities and is attributed to ground state depletion of the Eu@super +3@ activators. In addition, PL excitation

measurements revealed poor energy-transfer from the ZnGa@sub 2@O@sub 4@ host to the Eu@super +3@ ions. Cr-doping resulted in a saturated red-color and no host emission was observed over the entire current density regime investigated. The PL excitation of the ZnGa@sub 2@O@sub 4@:Cr@super +3@ revealed good overlap between the host emission and the O-Cr@super +3@ ligand-to-metal charge transfer absorption band. Cathodoluminescence efficiency and emission spectra of various compositions will be presented as a function of current density. The relevant energy transfer theory for the red emission in Eu@super +3@ and Cr@super +3@ doped ZnGa@sub 2@O@sub 4@ will be discussed. Finally, a process that integrates Cr@super +3@ (red), Mn@super +2@ (green) and intrinsic ZnGa@sub 2@O@sub 4@ (blue) into a single thin film for high-resolution field emission display applications will be shown.

10:40am **FP-TuM8 Molecular Organic Light-Emitting Devices based on a Guest-Host System**, *Z.H. Kafafi,* ***H. Murata****, L.C. Picciolo,* Naval Research Laboratory **INVITED**

This talk will review the molecular and electronic properties of the guests and hosts used in the active emissive layers in molecular organic light-emitting devices (MOLEDs), and the electrical and luminescent characteristics of MOLEDs with high efficiency, good thermal stability and extended lifetime. Saturated red, green and blue (RGB) emission based on a common host will be discussed in terms of energy transfer from the host to the guest molecules, and direct electron-hole recombination on the highly luminescent guest molecules. The mechanisms leading to high electroluminescence quantum efficiency and, good thermal and temporal stability will be discussed.

11:20am **FP-TuM10 Aging and Luminescent Characterization of Coated ZnS:Ag Phosphors in FED Systems**, ***G.R. Villalobos****, J.S. Sanghera, I. Aggarwal,* Naval Research Laboratory

Sulfide phosphors used in field emission displays (FED) tend to degrade (both physical and luminescent degradation) from interaction with the emitted electrons and residual gases in the device vacuum. A variety of coating types may protect the phosphors from degradation. For example, inert buffer coatings can isolate the phosphor from the residual gases in the device vacuum, electrically conductive coatings can reduce the surface charging, and thermally conductive coatings could reduce the heating from the electron beam on the phosphor surface. It is also possible that a layered structure composed of these individual coatings could be of benefit. We have scaled up a process that we developed to hermetically coat individual phosphor particles with various films. Whereas the laboratory-sized process could coat a half-gram of phosphor per day, the pilot plant scale system can coat up to 100 grams per day without a reduction in luminescent properties. To date we have deposited SiO@sub 2@, MgO, ITO, and Na(PO@sub 3@)@sub 6@ coatings on ZnS:Ag phosphors. The process allows a precise control over the thickness of the coating. Coating thicknesses of 5 to 90nm have been achieved. The process is continuous, is fully automated, and further scaleable to industrial sizes. The cathodoluminescent (CL) efficiency and aging behavior of the SiO@sub 2@ coated phosphor has been measured in both laboratory and FED devices. Aging tests have shown a dramatic improvement in aging behavior between the coated and un-coated phosphors. While phosphor efficiency and chromaticity are within 10% of uncoated values. Future work will include the measurement of the other coating materials.

11:40am **FP-TuM11 Temperature Dependence of Cathodoluminescent Degradation of ZnS Phosphor**, ***B. Abrams****,* University of Florida*; W. Roos,* University of the Orange Free State*; L.C. Williams, P.H. Holloway,* University of Florida

The effect of temperature on ZnS:Ag,Cl cathodoluminescent (CL) intensity and degradation by surface chemistry changes has been investigated using an Oriel optical spectrometer and a scanning Auger electron spectrometer. With vacuum pressures maintained between 3-5x10@super-9@ Torr, thermal quenching has been measured on the ZnS:Ag,Cl powder pressed into an Al cup and mounted onto a heater stage. Using a 2kV accelerating voltage, a constant current of 5μA and a 1mm spot size, the sample temperature was incrementally increased to 400@supero@C with CL and AES measurements being taken after each increase. AES data show little change in the S, Zn, O and C peaks on the surface as the temperature is increased. There is also no significant shift in Auger peak energies with temperature. The CL brightness decreased dramatically at T@>=@300@supero@C, while the maximum CL peak intensity shifted from 450nm to almost 600nm. CL brightness measurements taken as the sample was incrementally cooled back towards room temperature showed that the most intense CL peak shifted back to 450nm. However, a large hysteresis was observed in the CL intensity versus temperature data due to poor heat transfer. Recovery of the CL intensity upon returning to RT ranged from 70% recovery to 100% recovery dependent upon the hold time at each temperature. The mechanisms for these effects will be discussed. This work was supported by DARPA Grant MDA 972-93-1-0030 through the Phosphor Technology Center of Excellence.

Flat Panel Displays
Room 313 - Session FP+VT-TuA

Emissive Displays and Device Reliability

Moderator: D. Temple, Microelectronics Center of North Carolina

2:00pm **FP+VT-TuA1 Development and Characterization of Cu-Li Alloy Edge Field Emission Devices@footnote 1@**, ***J.C. Tucek***, *A.H. Jayatissa, A.R. Krauss, O. Auciello, D.M. Gruen, D.C. Mancini, N. Moldovan,* Argonne National Laboratory

Thin coatings (0.5 - 1 monolayer in thickness) of alkali metals applied to field emission devices are known to significantly enhance field electron emission. However, alkali metals are both physically and chemically unstable in layers exceeding a few Å in thickness, and therefore, it is extremely difficult to fabricate and maintain, during operation, such thin layers on FEAs. Lithium alloy films developed at Argonne National Laboratory provide very stable, low work function coatings that maintain a segregated monolayer of lithium on the surface of the alloy, even under adverse environmental conditions or ion bombardment. These Li-based alloy films have been incorporated into edge emission devices which have low emission thresholds (~3 V/μm), high emission current densities (~10 A/cm@sup 2@), and are physically robust. These devices have been operated in a continuous emission mode for up to 270 hours. After an initial decrease in the emission current level, the emission from the Cu-Li films reach a constant level at approximately 60% of the initial current level, in accord with the stability and the long-lived nature of the Cu-Li films. These devices have been tested in inert gas atmospheres at pressures up to 0.1 mTorr, and they emit (at 50% of the high vacuum level) without catastrophic failure. In addition, we will discuss experiments using a simulated flat panel display configuration and PEEM/FEEM imaging which provide information about the emission uniformity of these edge emitters. Finally, work on applications of the Cu-Li films in gated emission devices will be discussed. @FootnoteText@ @footnote 1@Work supported by the U.S. Department of Energy, BES-Material Sciences, under Contract W-31-109-ENG-38, ONR, and the Office of Naval Research and DARPA under contract N00014-97-F0905.

2:20pm **FP+VT-TuA2 Field Emission Characteristics of Carbon Nanotubes**, ***B.R. Chalamala***, *K.A. Dean, R.H. Reuss,* Motorola, Inc. **INVITED**

We will present a summary of our recent work on the field emission characteristics of carbon nanotubes, and discuss their application in functional vacuum microelectronic devices like field emission displays. Our study has two primary goals: gain a deeper understanding of the fundamental mechanisms, and obtain an insight into the impact of practical issues on device performance. In particular, we will present detailed studies on the emission characteristics of individual single walled carbon nanotubes including current saturation mechanisms, device behavior under adverse vacuum conditions, along with high resolution field emission images showing detailed structure.

3:00pm **FP+VT-TuA4 Current Density Saturation in FED Phosphors**, ***J.S. Lewis***, University of Florida; *G.O. Mueller, R. Mueller-Mach, T. Trottier,* Agilent Labs; *P.H. Holloway,* University of Florida

In recent years interest in low voltage phosphors has been prompted by the development of field-emission displays (FED's) which operate in the 0.5-6 kV range. Taking into account factors such as dwell time, power density, intrinsic efficiency, and penetration depth, the current densities involved in FED operation are of similar magnitude as those used in CRT's and projection tubes. While brightness typically increases with current, efficiency decreases at higher current densities. Due to the different operating conditions, increased characterization and understanding of saturation at low voltages is needed. Quantification of current density is difficult, since electron beams used to excite the phosphors generally exhibit a Gaussian current distribution. This leads to variation of current density, and potentially saturation effects, over the beam area. Gaussian beam shapes cause more severe saturation in the center of the beam spot where current density is higher, and 'blooming' effects cause a change in beam size or shape as current increases. Deconvolution of these effects is difficult, but new experimental techniques have been developed which for the first time allow the determination of saturation effects in terms of absolute efficiency (under FED conditions). An approach was developed for the determination of the current distribution, and thus the saturation of intrinsic efficiency is obtained as a function of true local current density. The data can be used to model performance under any arbitrary current distribution. Results will be presented for a variety of traditional CRT and projection tube phosphors, as well as newer phosphors for use in FED's. The mechanisms for saturation will be discussed. *This work partially supported by the Phosphor Technology Center of Excellence.

3:20pm **FP+VT-TuA5 Cathodoluminescence from Thin Film versus Powder Phosphors**, ***L.C. Williams***, *B. Abrams,* University of Florida; *W. Roos,* University of the Orange Free State; *P.H. Holloway,* University of Florida

Thin film cathodoluminescent (CL) phosphors have a number of potential advantages over powder phosphors, such as better mechanical integrity, better thermal heat sinking, more efficient use of material, and better planarity. However most CL screens use powder phosphors due to better brightness, efficiency, and crystallinity. In the current work, we have examined the effects of thin films versus powders on the rate of degradation of ZnS:Mn in residual vacuum gases. The ZnS:Mn thin films were RF planar magnetron sputter deposited onto glass/ITO substrates at a growth temperature of 160°C. The powders were simply cold compacted into shallow stainless steel sample holders. Degradation was shown to occur by the Electron Stimulated Surface Chemical Reaction (ESSCR) mechanism, in which the electron beam dissociated adsorbed oxidizing molecular species (e.g. H@sub 2@O) to cause conversion of luminescent ZnS:Mn to non-luminescent ZnO:Mn. The degradation was faster at low primary beam energy (0.5keV) versus high energy (5keV). Degradation was dependent upon the gas pressure and electron dose (versus time of exposure). Degradation of as deposited thin films was different from that for films annealed at 750°C for 5 minutes; this will be interpreted in terms of the point defect density of as deposited versus annealed phosphor films. After correction for the true surface area of powders versus films, the rate of degradation will be compared. The mechanisms leading to the different degradation rates for films versus powders will be discussed.

3:40pm **FP+VT-TuA6 Reliability of Silicon-based Field Emission Displays**, ***T. Akinwande***, Massachusetts Institutute of Technology **INVITED**

PLEASE SEND US AN ABSTRACT. Thank you.

4:20pm **FP+VT-TuA8 Illumination Sources for Laser-based Displays**, ***B. Bischel***, Gemfire Corporation **INVITED**

PLEASE SEND US AN ABSTRACT. Thank you.

5:00pm **FP+VT-TuA10 Oxide Phosphor TFEL Devices Fabricated by Magnetron Sputtering with RTA**, ***T. Minami***, *H. Toda, T. Miyata,* Kanazawa Institute of Technology, Japan

High luminance thin-film electroluminescent (TFEL) devices using various oxide phosphor thin films have been recently reported. However, a high luminance could only be obtained in these TFEL devices by postannealing in various atmospheres at high temperatures about 1000@super o@C. In this paper, we describe a procedure for producing high luminance TFEL devices with an oxide phosphor thin-film emitting layer prepared without high temperature postannealing: magnetron sputtering with rapid thermal annealing (RTA). TFEL devices were fabricated by depositing oxide phosphor thin films onto thick sintered BaTiO@sub 3@ insulating ceramic sheets. A Ga@sub 2@O@sub 3@:Mn or ZnGa@sub 2@O@sub 4@:Mn thin film was deposited by r.f. magnetron sputtering onto a substrate mounted on a rotating platform; a thin film was deposited onto the substrate when it passed over the target, and subsequently, RTA was performed on the deposited film when it passed over the halogen lamps. The sputter deposition under a platform rotation of 1-2 r.p.m. was carried out in an Ar+O@sub 2@ sputter gas atmosphere at pressures of 0.2-8 Pa with an rf power of 120 W. High luminance green emissions were obtained in TFEL devices using either a Ga@sub 2@O@sub 3@:Mn or a ZnGa@sub 2@O@sub 4@:Mn thin-film emitting layer prepared without postannealing at high temperatures under optimized deposition conditions. The Ga@sub 2@O@sub 3@:Mn and ZnGa@sub 2@O@sub 4@:Mn TFEL devices driven by a sinusoidal wave voltage at 1 kHz exhibited luminances of 24 and 200 cd/m@super 2@, respectively.

Flat Panel Displays
Room Exhibit Hall C & D - Session FP-TuP
Poster Session

FP-TuP1 Fabrication and Characterization of Blue Light Emission from a Well-Type Field Emitter Device Implementing a Thin Film ZnO:W Phosphor, ***V. Bhatia***, *H.R. Kim, M.H. Weichold,* Texas A&M University

Flat panel displays based on the principals of field emission, in theory, can delivery a picture quality comparable to a cathode ray tube at lower voltages with efficient phosphors. Microtip fabrication and availability of low voltage blue light emitting phosphors have been some of the key issues of research for the commercialization of these displays. This paper presents the fabrication of lateral edges as electron sites to produce blue light from the co-deposited thin film of zinc oxide and tungsten. The phosphor used in the lateral edge field emitter device has been fabricated at Texas A&M University@footnote 1@ by co-depositing zinc oxide and tungsten and annealing the thin film under appropriate annealing conditions. Phosphor emits blue light (490nm) at voltages as low as 300 V. It has been determined that the formation of ZnWO@sub 4@ was responsible for the emission of blue light.@footnote 2@ The device design to implement the blue phosphor is based on the design provided by L. D. Karpov.@footnote 3@ For the emission of electrons to excite phosphors, emitters have been fabricated by a combination of metal-carbon-metal layers as the lateral edges of wells formed in a dielectric material. Phosphors are fabricated at the bottom of the wells above anode lines. The fabrication steps of the blue light emitting lateral edge emitter along with phosphor characterization, efficiency measurements, and current-voltage characterization are presented in this paper. @FootnoteText@@footnote 1@Technology Disclosure to TAMU Technical Licensing Office (1993). @footnote 2@J. B. Sobti, P. M. Babuchna, V. Bhatia, M. H. Weichold. Paper presented at Spring, 1999, MRS meeting. @footnote 3@L. D. Karpov, V. A. Dratch, V. S. Zasemkov, A. P. Genelyev, Y. V. Migorodsky, and S. B. Proskournin. Technical digest of the 6th International vacuum Microelectronics Conference, Newport, RI, 1993.

FP-TuP2 Optical Filters for Plasma Display Panels using Organic Dyes and Sputtered Multilayer Coatings, ***T. Okamura***, *S. Fukuda, K. Koike, H. Saigou, M. Yoshikai, M. Koyama, T. Misawa, Y. Matsuzaki,* Mitsui Chemicals, Inc., Japan

We describe optical filters for plasma display panels (PDP). PDP emit strong electromagnetic (EM) radiation and intense near-infrared light (NIR). The EM radiation is limited by regulations, and NIR emission causes malfunctions of devices working through NIR. The essential constituents of the developed optical filter are sputtered multilayer coatings and dye-containing layers. The sputtered multilayer coatings comprising alternate layers of metal and high-refractive material show both EM shielding effect and NIR cut-off ability without sacrificing high visible-light transparency. In addition, their reflectance should be reduced in order to improve viewability. Therefore the multilayer coatings are designed by utilizing optical admittance loci and the admittance diagrams to minimize interfacial reflection between the multilayer and the polymeric layer adjacent to it which protects the multilayer coatings and is used for adhering polymeric film such as an anti-reflection film. We obtained 7-layer (Silver and Indium-Tin-Oxide) coatings on polyethylene terephthalate substrates by roll-to-roll process, with surface resistance of 2.2@ohm@/sq., NIR transmittance of 1~12 % in 800~1200nm, visible-light transmittance > 74%, and interfacial reflectance < 0.5%. Since transparent colors of these coatings are usually greenish, we used dyes to neutralize the transparent color. The dyes are also applied to control color temperatures and minimum perceptible color differences of PDP. For this purpose, we have also developed a software tool to simulate optical designs for a given emission spectrum of PDP. The performance of this tool will be also presented.

FP-TuP3 Fabrication of a Planar Field Emitter Array on the Diamond Like Carbon Layer, ***D.H. Lee***, *D.W. Kim,* Sungkyunkwan University, Korea*; S.I. Kim,* Skion Corporation, Korea*; G.Y. Yeom,* Sungkyunkwan University, Korea

Diamondlike carbon(DLC) based field emitters can be practically important in the fabrication of field emission display not only due to the properties possessed by diamond such as electronegativity, thermal stability, mechanical hardness, and chemical inertness but also due to the possibility of low temperature deposition and large area deposition. In this study, a novel DLC-based field emission device based on a planar field emitter has been designed and fabricated and its electrical properties were investigated. To maximize the field emission of the planar type field emitter, the shape and dimension of the device were simulated using a simulation tool. The deposition technique of DLC layer is very important because it can vary the emission properties of the fabricated DLC field emitter. To obtain desirable properties of DLC layer, a novel Cs ion assisted magnetron sputtering deposition technique developed by SKION Inc. was used to deposit the DLC layer at room temperature. The room temperature deposited DLC layer showed mechanical and electrical properties close to diamond The fabricated planar type DLC-based field emission device was consisted of DLC/bottom electrode/insulator/top electrode. The bottom electrode has a circular opening to expose the field emitting DLC layer. The slope of the bottom electrode opening, the thickness of the insulator layer, and the opening of the top electrode in addition to their materials were optimized to obtain a stable FED structure and the necessary electric field for electron emission and convergence of the electron beam. Details of the fabrication techniques and the electrical properties of the fabricated field emission devices will be discussed. Also, the properties of DLC layer deposited by Cs ion assisted magnetron sputtering will be also discussed.

FP-TuP4 Effects of ZnO Buffer Layer on the Luminous Properties of Thin Film Phosphors Deposited on ZnO/ITO/Glass Substrate, ***Y.J. Kim***, *Y.H. Jeong, S.M. Jeong,* Kyonggi University, Korea

Thin film phosphors deposited on ITO(Indium tin oxide) coated glass panel have a disadvantage of lower cathodoluminescent brightness than powder types due to the poor crystalline quality. It is very difficult for thin film phosphors to have high quality crystal structures, because ITO has an amorphous like structure. To improve the cathodoluminescent properties of thin film phosphors, ZnO buffer layer was deposited by sputtering methode between thin film phosphors and ITO coated glass substrate. All thin film phosphors were deposited by rf magnetron sputtering method. Transparent c-axis preferentially oriented ZnO thin film buffer layer could be obtained on ITO thin film, while ITO had an amorphous like structure. ZnGa@sub 2@O@sub 4@:Mn and CaTiO@sub 3@:Pr thin film phosphors were used to evaluate the effects of ZnO buffer layer. The crystal structures of thin film phosphors deposited on ZnO/ITO/glass substrate were developed better than those on ITO/glass, consequently the formers showed cathodoluminescent intensity at least twice as high as the latter. CaTiO@sub 3@:Pr and ZnGa@sub 2@O@sub 4@:Mn thin film phosphors showed sharp CL emissions at 613nm and 509nm, respectively.

FP-TuP5 Investigation of the Outgassing Characteristics of the Materials Consisted of Plasma Display Panel, ***H.R. Han***, *Y.J. Lee, G.Y. Yeom,* Sungkyunkwan University, Korea

In the fabrication of PDP, before filling with light emitting gases (Xe+Ne, etc.) to the fabricated panel, the panels are exhausted through a small section glass pipe attached to one side of the rear glass substrate of the panel. Currently, this gas exhausting takes more than several hours to obtain a desirable vacuum state of around 10@super -7@Torr due to the outgassing from the materials inside of the panel. It is known that this gas exhausting process is one of the most time-consuming processes that reduces the production rate and increases the cost of PDP. However, at present, the affecting factors or the materials causing the severe outgassing from the panel during the exhausting are not well understood due to the variety of materials and complex processing involved in the fabrication of the PDP. In this study, outgassing characteristics of the materials consisted of PDP and PDP panel itself were systematically studied using a thermal desorption technique to understand the origin of the severe outgassing. The characteristics of outgassing were investigated as a function of time and temperature. As the investigated materials, electrode(metal, ITO), dielectric films, barrier rib, fluorescent films, protective layer(MgO), and frit on the glass panel and the multilayer of these materials consisted of PDP panel were used and they were heated up to 500°C. Also, these materials were kept at 350°C for a few hours to measure outgassing characteristics at 350°C which is the temperature used for the exhausting process in the fabrication of PDP. The result showed that the maximum outgassing temperature from the single materials was varied from 100°C to 150°C. Mass spectrometry measurements of the materials maintained at 350°C have shown that the severe outgassing is primarily related the MgO and fluorescent films. These behaviors were compare with outgassing from the complete panel.

FP-TuP6 Characterization of Radio Frequency Magnetron Sputter-deposited Ga@sub 2@O@sub 3@:Mn Phosphors of Thin Film Electroluminescent Display Devices, *J.S. Lewis, **J.H. Kim**, P.H. Holloway,* University of Florida

Manganese-activated Ga@sub 2@O@sub 3@ phosphor thin films as the emitting layer of alternating current thin film electroluminescent (ACTFEL) display devices have been prepared by radio frequency (rf) magnetron sputtering of a Mn-doped Ga@sub 2@O@sub 3@ target in a pure argon or an oxygen-argon mixture atmosphere. The structural and compositional properties of the deposited Ga@sub 2@O@sub 3@:Mn phosphor thin films have been systematically investigated as a function of the sputter deposition parameters, such as rf power, working pressure, oxygen gas concentration, and substrate temperature ranging 5 - 50 W, 5 - 30 mTorr, 0 - 50 %, and room temperature - 400 °C, respectively. The surface morphology, structure, and composition of the deposited Ga@sub 2@O@sub 3@:Mn films were characterized by atomic force microscopy (AFM), scanning electron microscopy (SEM), X-ray diffraction (XRD), and energy dispersive X-ray spectroscopy (EDS). Their electroluminescent and photoluminescent characteristics were also evaluated and correlated with the results of the structural and compositional analyses. The ACTFEL display devices were fabricated using the conventional structure, Al/BTO/Ga@sub 2@O@sub 3@:Mn/ATO/ITO/glass, and the inverted structure, ITO/BTO/Ga@sub 2@O@sub 3@:Mn/PZT/Au/Al@sub 2@O@sub 3@.

FP-TuP7 Fabrication of a Microchannel Plate for a FED by Solution-based Multilayer Thin Film Coating, ***S. Yu**, T. Jeong, J. Lee, S. Jin, W. Yi, J. Heo, J.M. Kim,* Samsung Advanced Institute of Technology, Korea

To develop a high efficient field emission display (FED), a special microchannel plate (MCP) was incorporated in a FED, where field-emitted electrons are amplified in the cylindrical holes of a MCP by action of secondary electron emission from the emissive layer, and MCP characteristics are examined. We fabricated an alumina-based MCP with many micrometer-sized cylindrical holes by computerized punching and firing of the laminated alumina green sheet, where the aspect ratio of the hole was chosen to be around 13. Solution-based hybrid layer coating was utilized for MCP fabrication. Cu electroless coating was applied to a MCP, then Cu layer was oxidized to be a conductive layer on the surface of the hole. Tetraethyl orthosilicate (TEOS) containing solution was spin coated on the copper oxide layer. Consequent firing resulted in a SiO2 thin layer as an emissive layer. Then electrodes on the two faces of a MCP were deposited by an e-beam evaporator. To optimize the MCP fabrication process, we followed the design of experiment (DOE) scheme. We chose three DOE factors: Cu layer thickness controlled by the Cu electroless coating time (10 and 15 minutes), Cu oxidation temperature (570, 800, and 1030 C), and TEOS concentration (0.015 M and 0.007 M) for SiO2 layer thickness. We measured the current amplifying gain of our MCP by an e-gun. The highest gain was obtained to be about 10 for the sample with 15 min Cu coating time, 1030 C oxidation temperature, and 0.007 M TEOS concentration, where this gain will be beneficial for a new kind of FED by increasing the intensity of cathodoluminescence. Further experiments by varying other experimental factors are undergoing, and good results are expected.

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