# Tuesday Afternoon, October 3, 2000

## 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.

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