Flat Panel Displays Topical Conference
Room 604 - Session FP+VT-MoM
Field Emission Displays and Vacuum Packaging Issues
Moderator: W. Weed, Sandia National Laboratories

8:20am **FP+VT-MoM1 A New Field Emission Device with Improved Vacuum Features*, V.P. Mammana,*** Instituto de Física - Universidade de São Paulo, Brazil*; F.T. Degasperi,* Faculdade de Tecnologia de São Paulo - FATEC/SP, Brazil*; O.R. Monteiro,* Lawrence Berkeley Laboratory*; J.H. Vuolo, M.C. Salvadori,* Instituto de Física - Universidade de São Paulo, Brazil*; I.G. Brown,* Lawrence Berkeley Laboratory

We introduce in this article a novel geometry that can be used in the manufacturing of field emission displays that combines superior vacuum conductance and field enhancement factors. A theoretical model is developed for the calculation of the upper limit of the electrostatic field at the emitting regions, and these values are compared to those calculated for the actual geometry. The vacuum conductance of the proposed geometry is also calculated, and we show that conductances up to an order of magnitude higher than other schemes are readily achievable.

8:40am **FP+VT-MoM2 Fabrication of a Well-Type Field Emission Device with a Tungsten Doped Zinc Oxide Thin Film Phosphor*, V. Bhatia*,** *J.B. Sobti, L.D. Karpov, M.H. Weichold,* Texas A&M University

Interest in the area of the field emission displays (FEDs) exists because of combination of the positive features of a cathode ray tube with flat panel display technologies. High resolution at low cost, power efficiency at low voltage operations, wide viewing angles, and operation under variable temperatures are some of the important features of an FED. This paper reports the fabrication of a monochromatic display of blue light from a lateral edge well emitter. A high-resolution display has been fabricated using a blue phosphor developed at TAMU@footnote 1@ in conjunction with a well type edge field emission device designed by Karpov et al.@footnote 2@ The FED has been formed by constructing arrays of wells, having sides of a dielectric material above a matrix of anode lines. The anode lines lie underneath the phosphor. In the diode design of the device, cathode lines are fabricated by depositing metal-carbon-metal layers, atop the well sides, hanging slightly over the well edges. The FED design reported here provides an extra measure of brightness to the display by reflecting the light from anode lines out of well towards the viewer. Since the device eliminates the fabrication of microtips, the display involves simpler fabrication steps, more ruggedness, and stability than conventional FEDs. The phosphor being used in this display, has been fabricated by co-depositing zinc oxide and tungsten (ZnO:W). This phosphor has been reported to emit blue light at 490 nm when excited at 300 V.@footnote 3@ This paper presents ongoing research in integrating the ZnO:W phosphor in the well type edge field emission display. The fabrication steps involved in making the display device are presented as are emission properties and current-voltage characteristics to determine the performance of the display. @FootnoteText@ @footnote 1@Technology Disclosure to TAMU Technical Licensing Office (1993). @footnote 2@L. D. Kapov et al. 7th Int'l Vacuum Microelectronics Conf., France 1994. @footnote 3@J. B. Sobti et al. MRS meeting, Spring 1998.

9:00am **FP+VT-MoM3 Effects of Residual Gas Exposures on the Emission Characteristics of Field Emission Arrays*, R.M. Wallace*,** *B.E. Gnade,* University of North Texas*; B.R. Chalamala,* Motorola Flat Panel Display Division **INVITED**

Field emitter arrays have been introduced as a potential component for flat panel display technologies. A key issue for reliable performance includes the consideration of the device vacuum ambient in the course of packaging the display. In this paper, we review the effects of residual gas species on the emission characteristics of field emitter arrays under carefully controlled UHV conditions. We also examine recent work in the community on controlling the tip morphology, the tip surface chemistry, and the sources of residual gas species in displays.

9:40am **FP+VT-MoM5 Pressure Field Detailed Calculations for a New Field Emission Device with Improved Vacuum Features@footnote 1@*, F.T. Degasperi,*** Faculdade de Tecnologia de São Paulo - FATEC/SP - Brazil*; V.P. Mammana,* Instituto de Física da Universidade de São Paulo, Brazil

The vacuum characteristics are an important consideration for field emission devices, mainly because of the high area/volume ratio presented in these devices. Dessorption associated with relatively small conductances can degrade the device performance over its lifetime, if small distances between the cathode and the anode are set. The proposal of a novel geometry for these devices@footnote 1@ seeks superior vacuum conductance, while maintaining a high electric field enhancement factor. It is of great importance to determine the pressure distribution along the emission chamber of the proposed device, since the emission performance is strongly dependent on this pressure. The usual vacuum technology approach considers a vacuum system made up of discrete elements. This approach is very useful, but leads only to the knowledge of the average pressure, and not to the detailed pressure distribution. In this article we calculate the pressure distribution considering the degaseification effect from several surfaces of the device, which allows us to predict its vacuum behaviour in a more realistic situation. @FootnoteText@ @footnote 1@ see "A new field emission device with improved vacuum features".

10:00am **FP+VT-MoM6 Cathodoluminescent (CL) Degradation Mechanism for ZnS-Based Phosphors and the Impact on Field Emission Displays (FEDs)*, B.L. Abrams,*** *W. Roos,* University of Florida*; H.C. Swart,* University of the Orange Free State*; P.H. Holloway,* University of Florida

The surfaces of ZnS powder and thin film phosphors have been subjected to electron beam bombardment.Simultaneous acquisition of CL brightness data and Auger Electron Spectroscopy(AES)data have revealed a correlation between surface chemical reactions and CL degradation.The data were collected in a stainless steel UHV chamber.In the presence of a 2kV primary electron beam in 1e-6 Torr of H2O,the amounts of C and S on the surface decreased while the O concentration increased.XPS data showed that ZnO formed on both the samples.This change in surface chemistry coincided with a decrease in CL brightness.Our model of electron beam stimulated surface chemical reactions(ESSCR)for this degradation process postulates that the primary electrons dissociate physisorbed molecules to reactive atomic species. These atomic species remove surface S and C as volatile SOx and H2S species allowing formation of a non-luminescent ZnO layer in 1e-6 Torr water.However,in a vacuum of 1e-6 Torr dominated by hydrogen and with a low water content, there was no decline in S,no rise in O,but the CL still degraded.These effects are still attributed to ESSCR due to hydrogen assisted by thermal effects.Hydrogen is postulated to dissociate under the electron beam and remove S as H2S while Zn volatilizes due to a high vapor pressure and elevated temperatures from electron beam heating.The desorption of various ions or molecules from the surface of the phosphor caused by surface chemical reactions contaminate the vacuum inside the display tube and create a reactive environment.These reactive atoms or molecules may adsorb,react and consequently form an absorbed or coated layer(sulfide or oxide)on the field emitter tip on the cathode side of the FED.It is thus suggested that the ESSCR mechanism is important to degradation both of the phosphor on the anode and the field emitter tips on the cathode.This work was supported by Darpa Grant MDA 972-93-1-003 through the Phosphor Technology Center of Excellence.

10:20am **FP+VT-MoM7 A Novel Electron Emission Flat Panel Display Using Cesiated Amorphous Diamond Planar Emitter Structure*, S. Kim,*** *M.H. Sohn, Y.S. Park, N.W. Paik, B. Lee,* SKION Corporation*; Y.H. Lee,* Sung-Kyun-Kwan University, S.Korea, Korea*; D.H. Lee, Y.J. Sung,* Sung-Kyun-Kwan University, S.Korea*; G.Y. Yeom,* Sung-Kyun-Kwan University, S.Korea, Korea

Oxidized cesiated amorphous diamond films have been developed for electron emitters. The work function of the surface is as low as 1.05 eV. The work function, chemical composition and structure are found to be stable even after annealing at temperatures up to 700 degree C. A very low turn-on field of 5-7 V/µmm is obtained by a planar geometry field emission measurement. A unique Pierce-type planar electron extraction geometry has been developed for flat panel display applications. Unlike field emission from a sharp point, the structure produces a long focal length beam of the order of few centimeters. In this paper, the fabrication procedure of the emitter structure and its emission properties will be presented.

10:40am **FP+VT-MoM8 Field Emission Properties of Conformal and Non-Conformal Diamond Film Coatings on Si Microtip Electron Emitters**, *M.Q. Ding,* Beijing Vacuum Electronics Research Institute, China*;* ***A.R. Krauss****, O. Auciello, D.M. Gruen, Y. Huang,* Argonne National Laboratory*; V.V. Zhirnov,* Semiconductor Research Corp.*; E.I. Givargizov, A. Stepanov,* Institute of Crystallography, Russia

Non-conformal and conformal nanocrystalline diamond films were deposited on single needle-shaped Si tip emitters, using hot filament chemical vapor deposition (HFCVD) and microwave plasma-enhanced chemical vapor deposition (MPECVD), respectively. The HFCVD diamond was deposited in the form of large single crystal grains at the end of the microtips, whereas the nanocrystalline diamond films were uniformly thick conformal coatings. The threshold voltages for cold cathode electron emission were measured for Si microtips as a function of both the thickness of the diamond coating and the radius of the Si tips. The threshold voltages for the single crystal HFCVD coatings were found to vary with both the tip radius and diamond film thickness. For the nanocrystalline films, the threshold fields were found to be significantly lower than the uncoated tips, and nearly independent of both Si tip radius and film thickness. In this case, the behavior is consistent with field emission that is determined largely by local electric field enhancement associated with intrinsic film properties. A model is presented in which the field enhancement occurs at sp2-bonded grain boundaries. Work supported by the U.S. Department of Energy, BES-Materials Sciences, under Contract W-31-109-ENG-38, and ER-LTR CRADA No. C9501501 with SI Diamond Technology, Inc., Austin, TX, and DARPA/ONR under Contract N00014-97-F0305

11:00am **FP+VT-MoM9 Fabrication of Aligned High-density Diamond Needles by Dry Etching of Diamond Substrates***, E.S. Baik,* Myong Ji University, Korea*; Y.J. Baik,* Korea Institute of Science and Technology, Korea*; **D. Jeon**,* Myong Ji University, Korea

Densely packed diamond needles aligned in the same direction are formed by air plasma etching of diamond substrates. Diamond substrates were coated with a thin layer of Mo and then etched by RF or DC plasma with the substrate biased at negative several hundred volts. The shape and the density of the diamond needles could be reproducibly controlled with the etching parameters such as the substrate temperature, pressure, bias voltage, power, and the amount of Mo. If the substrate temperature was high, for example, the needles became thick. Mo acted as an etch-resistant mask for the needle formation. Mo was sometimes self-supplied by the sputtering of the Mo substrate holder during the etching, but the uniformity of the needles could be best controlled by coating small amount of Mo before etching. If the amount of Mo or the pressure was not adequate, the needles did not form or formed only along the edge of the diamond grains. With the optimum condition, we could fabricate sharp diamond needles whose pillar diameter and height were 0.1 µm and 3 µm, respectively. The density was 30 needles/µm@super 2@. Since the needles were highly aligned and always formed in parallel with the field, the direction of the needles could be chosen by tilting the substrate. Not only the polycrystalline diamond films but also the high pressure/high temperature diamond and the natural diamond could be etched to form needles. Our diamond needles can be utilized as the field emission cathode tips, diamond fiber for composite materials, highly efficient heat sinks for their large surface area, and sensors.

11:20am **FP+VT-MoM10 Hermetic Sealing and Evacuation of Candescent's ThinCRT@superTM@***, **T.S. Fahlen**,* Candescent Technologies Corporation **INVITED**

Candescent has developed a full color, full video, power efficient display, the ThinCRT@superTM@ based on Spindt-type field emitters with very low voltage switching (<10.5 volt), and "high voltage" (6 KV) aluminized phosphors. Because of the high voltage used, the faceplate (anode/phosphor screen) and backplate (cathode) of the display are separated by 1.25 mm. This talk describes two methods used to hermetically seal the perimeter and evacuate ThinCRT displays. In both methods, the faceplate and backplate are sealed to a frame made of glass frit placed between them following an accurate, room temperature and atmospheric pressure alignment procedure. One sealing method uses a laser to first seal the frit frame to the faceplate, and then to hermetically seal the backplate to this assembly in a vacuum environment; no exhaust tubulation is required, and a non-evaporable getter is incorporated along one internal border of the display. A second method uses a laser to seal the frit frame to the faceplate, and the backplate to the frame/faceplate assembly but in a non-vacuum environment. An auxiliary chamber (AC) containing a getter and exhaust tube is then oven sealed to the rear of the assembly. Holes in the backplate allow the gases in the interior of the display to flow into the AC. The display assembly is then evacuated through an exhaust tubulation. The AC saves border space by allowing the getter to be removed from the display border to the rear of the display. The AC adds no additional thickness to the display because it protrudes no further than do the display electronics which are also attached to the rear of the display. In both sealing methods, the exact spacing between the faceplate and the backplate is determined solely by the internal support structure. The frit frame and sealing process have been designed so that during laser sealing, the frit expands to fill and seal the small gap left between the frit frame and the faceplate.

Author Index

Bold page numbers indicate presenter

— A —
Abrams, B.L.: FP+VT-MoM6, **1**
Auciello, O.: FP+VT-MoM8, 1
— B —
Baik, E.S.: FP+VT-MoM9, 2
Baik, Y.J.: FP+VT-MoM9, 2
Bhatia, V.: FP+VT-MoM2, **1**
Brown, I.G.: FP+VT-MoM1, 1
— C —
Chalamala, B.R.: FP+VT-MoM3, 1
— D —
Degasperi, F.T.: FP+VT-MoM1, 1; FP+VT-MoM5, **1**
Ding, M.Q.: FP+VT-MoM8, 1
— F —
Fahlen, T.S.: FP+VT-MoM10, **2**
— G —
Givargizov, E.I.: FP+VT-MoM8, 1
Gnade, B.E.: FP+VT-MoM3, 1
Gruen, D.M.: FP+VT-MoM8, 1
— H —
Holloway, P.H.: FP+VT-MoM6, 1
Huang, Y.: FP+VT-MoM8, 1
— J —
Jeon, D.: FP+VT-MoM9, **2**
— K —
Karpov, L.D.: FP+VT-MoM2, 1
Kim, S.: FP+VT-MoM7, **1**
Krauss, A.R.: FP+VT-MoM8, **1**
— L —
Lee, B.: FP+VT-MoM7, 1
Lee, D.H.: FP+VT-MoM7, 1
Lee, Y.H.: FP+VT-MoM7, 1
— M —
Mammana, V.P.: FP+VT-MoM1, **1**; FP+VT-MoM5, 1
Monteiro, O.R.: FP+VT-MoM1, 1
— P —
Paik, N.W.: FP+VT-MoM7, 1
Park, Y.S.: FP+VT-MoM7, 1
— R —
Roos, W.: FP+VT-MoM6, 1
— S —
Salvadori, M.C.: FP+VT-MoM1, 1
Sobti, J.B.: FP+VT-MoM2, 1
Sohn, M.H.: FP+VT-MoM7, 1
Stepanov, A.: FP+VT-MoM8, 1
Sung, Y.J.: FP+VT-MoM7, 1
Swart, H.C.: FP+VT-MoM6, 1
— V —
Vuolo, J.H.: FP+VT-MoM1, 1
— W —
Wallace, R.M.: FP+VT-MoM3, **1**
Weichold, M.H.: FP+VT-MoM2, 1
— Y —
Yeom, G.Y.: FP+VT-MoM7, 1
— Z —
Zhirnov, V.V.: FP+VT-MoM8, 1