Wednesday Morning, November 4, 1998

Vacuum Technology Division
Room 329 - Session VT-WeM

Vacuum Microelectronics

Moderator: J.W. Weed, Sandia National Laboratories

9:00am **VT-WeM3 Electron Beam Degradation of Sulfide-Based Thin Film Phosphors for Field Emission Flat Panel Displays**, ***B.L. Abrams,*** University of Florida, Gainesville*; T.A. Trottier,* Motorola*; H.C. Swart,* University of the Orange Free State, Republic of South Africa*; E.S. Lambers, P.H. Holloway,* University of Florida, Gainesville

The change in cathodoluminescence (CL) brightness and changes in surface chemistry of the thin film phosphor, SrS:Ce, have been investigated using a scanning Auger electron spectrometer and an Orial optical spectrometer. The data for SrS:Ce were compared to ZnS:Cu,Cl,Au and Y@sub 2@O@sub 2@S:Eu powders all collected in a stainless steel UHV chamber with gas pressures of 10@super -6@ Torr O@sub 2@. In the presence of a 2kV primary electron beam, the amounts of C and S on the surface decreased while the oxygen concentration increased. As a result, ZnO, Y@sub 2@O@sub 3@ and preumably SrO@sub x@ formed. This change in surface chemistry coincided with a decrease in CL brightness. SrS degraded much faster than ZnS of Y@sub 2@O@sub 2@S. The model for this degradatin process suggests that the primary electron beam dissociated physisorbed molecules to reactive atomic species. These atomic species reacted with surface S and C, carrying them away and leaving behind an increasingly more impenetrable layer. Threshold voltage experiments were conducted to reveal where it becomes possible to measure the CL. This threshold voltage should be affected by the oxide layer discussed above. The implications for vacuums in an FED FPD will be discussed. This work was supported by Darpa grant MDA 972-93-1-0030 through the Phosphor Technology Center of Excellence

9:20am **VT-WeM4 Current Status of Field Emission Displays (FED's)***, **B.E. Gnade,*** Defense Advanced Research Projects Agency **INVITED**

Over 12 years have passed since the first field emission display (FED) prototype was built by LETI, France; this was a 5Ó diagonal, 1/4 VGA monochrome screen. At present, commercially available screens of similar design are beginning to emerge. These displays, manufactured by PixTech Inc., are based on a low-anode-voltage (<1kV) concept and are geared primarily for instrumentation applications. However, FED screens of superior image quality, including brightness and color purity, must be produced in order to challenge AMLCDs and ultimately the CRT beyond niche applications. To this end, Motorola adopted a high-anode-voltage approach to FED design that results in full-color, sun-light readable FED prototypes. In my presentation, I will address some of the challenges faced in producing a high-anode-voltage FED. In addition, I will describe some of the ongoing efforts at Motorola to produce still more readily affordable and reliable displays, such as those based on carbon cathodes.

10:00am **VT-WeM6 Thin Film and Powder Phosphors for Field Emission Flat Panel Displays**, ***P.H. Holloway****, S. Jones, T.A. Trottier, J. Sebastian, B.L. Abrams, J. Thomes,* University of Florida, Gainesville*; H.C. Swart,* University of the Orange Free State, Republic of South Africa **INVITED**

Field emission displays (FEDs) are now available in the market place as monochrome product, and full color displays are available for engineering evaluation. Critical to the success of the full color display will be the performance and lifetime of the red, green and blue phosphors. The effects of operating voltage, current density, residual vacuum and phosphor, tip interactions will be discussed. The critical parameters are the phosphor brightness, efficiency, and lifetime, which are impacted by numerous factors. Reduced saturation effects have been demonstrated in FED phosphors by reducing the luminescent lifetime so that luminescent centers may be excited multiple times during one writing cycle. Charging of phosphors, especially at low voltages, has been studied and new models developed which may lead to better control through processing. Considerable progress has been achieved in understanding the limited lifetime and the phosphor/tip interaction. The surface chemistry of the phosphors is critical to brightness and efficiency, and electron beam stimulated surface chemical reactions with residual vacuum gases have been shown to dominate the evolution of surface chemistry. This is particulary true for sulfur-containing phosphors, but also true for oxide-based phosphors as well. This mechanism will be reviewed in detail, and the effects on FED phosphors will be discussed.

10:40am **VT-WeM8 A Poor Vacuum Tolerant, Low-Voltage, Scalable, Thin-Film-Edge Dispenser Field Emitter Array***, **D.S.Y. Hsu,** H.F. Gray,* Naval Research Laboratory **INVITED**

A new low-voltage, poor-vacuum-tolerant, area-scalable, field emitter array (FEA) electron source has been developed for field emitter displays (FEDs). The new FEA cell has a horizontal gate to minimize capacitance and a vertically oriented multi-layer thin-film-edge dispenser field emitter. This multilayer thin-film emitter is made with alternating high work function and low work function metal thin films with a total thickness in the range of 60-75 nm. The FEA cell aperture diameter is about 400 nm and the height of the emitter is about 0.5 micrometers. Spacing between the gate aperture edge and the emitter film is about 75-90 nm. This new FEA, based on chemical beam deposition, is fundamentally self aligned and should not depend on high resolution lithography. All dimensions are totally independent; that is, the FEA cell aperture diameter, spacing between gate edge and emitter, emitter height, insulator thickness, gate thickness, number of multi-layers, thickness of multi-layers, etc. can be independently designed without effecting the other dimensions. The number of processing steps is less than 1/3 the number required for other FEAs. We have measured single FEA cell emission of about 5-10 microamps using an extraction voltage of 60 volts and about 10 nanoamps with 30 volts. We have also observed no emission degradation after repeated cycling from 10@super -8@ to 10@super -6@ torr of room air. No activation procedures are required and exposure to atmosphere has no measurable effect.

11:20am **VT-WeM10 Diamond Coated Silicon Field Emitter Array***, S. Albin, **W. Fu,*** Old Dominion University*; G.R. Myneni,* Thomas Jefferson National Accelerator Facility

Diamond coated silicon tip arrays, with and without a self-aligned gate, were fabricated and their I-V characteristics were measured. Sharp silicon tips were prepared by a wet etching technique. For samples without the gate, the silicon array was selectively nucleated at the tip region using ultrasonic agitation in a 10-nm diamond suspension. CVD diamond films were grown uniformly on the tips with a negative bias on the substrate to enhance the diamond growth. The arrays were tested for current emission under a vacuum of 10@super -6@ torr. A piece of polished silicon was used as anode with a 2-@micron@ thermal oxide spacer. An emission current of 50 @mu@A was obtained at 5 V from an array of 400 tips. The I-V curve of the diamond coated silicon arrays showed typical diode characteristic under forward and reverse bias. To fabricate the self-aligned gate structure, 1-@micron@ thermal oxide was grown on the etched samples followed by deposition of 0.2 @micron@ tungsten as a gate metal using RF sputtering. After planarization by etch back, the exposed gate metal and oxide were removed from the tips. Diamond films were grown selectively on the silicon tips. A copper anode was placed 200 @micron@ away from the array surface with an applied voltage of 400 V. The turn-on gate voltage was found to be 40 V for the gate aperture of about 1.5 @micron@. An emission current of 3 @mu@A was obtained from an array of 400 tips at a gate voltage of 80 V. Our technique shows the potential for development of diamond based low voltage vacuum electronic devices and field emission based micro sensors.

11:40am **VT-WeM11 Field Emission Characteristics of SiC Capped Si Tip Array by Ion Beam Synthesis***, D. Chen, **W.Y. Cheung**, S.P. Wong, Y.M. Fung,* The Chinese University of Hong Kong, Hong Kong*; J.B. Xu,* The Chinese University of Hong Kong, China*; I.H. Wilson,* The Chinese University of Hong Kong, Hong Kong*; R.W.M. Kwok,* The Chinese University of Hong Kong, China

High dose carbon implantation into Si tip array and Si wafer using a high beam current density Metal Vapor Vacuum Arc ion source were performed to synthesis SiC/Si heterostructure tip array. Silicon tip array were prepared by anisotropic chemical etching. An implantation energy of 35keV was used to a dose of 1.0*10@super18@ ions/cm@super2@ were performed and subsequent annealing in argon ambient at 1200@supero@C for various time were performed to form SiC capping layer. Scanning Electron Microscopy (SEM) revealed the Si are sharp and uniformly arranged. X-ray photoelectron showed that a thin surface SiC layer has been formed. Electron Field Emission characteristics have been measured using a diode structure by using a spacer in an ultra-high vacuum chamber with a base pressure better than 2*10@super-8@ torr. Results shown that electron emission properties depend on the processes conditions of the these samples. Typical turn-on field and emission current density are about 2.5 V/mm and 1mA/cm@super2@, respectively. These results were compared with that of planar structure prepared by ion implantation into Si wafer.

The dependence of the electron emission mechanism on the surface morphology and the structure of the samples will be presented and discussed. This work is supported in part by the Research Grants Council of Hong Kong (Ref. No. CUHK513/95E)

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