Electronic Materials and Devices
Room 310 - Session EM+SC+OF-WeA

Future Issues in Electronics and Optoelectronics
Moderator: C.R. Eddy, Jr., Naval Research Laboratory

2:00pm **EM+SC+OF-WeA1 Materials Issues in Solid-State Lighting***, J.Y. Tsao,* Sandia National Laboratories **INVITED**

A quiet revolution is underway. Over the next 10-15 years inorganic-semiconductor-based solid-state lighting (SSL) technology is expected to outperform first incandescent, and then fluorescent and high-intensity-discharge, lighting.@footnote 1@ Nevertheless, SSL is in its infancy, and significant challenges must be met for SSL to achieve its potential for general white lighting. In this talk, we give an overview of these challenges, and of the prospects for overcoming them. We will focus especially on challenges related to the wide-bandgap AlGaInN family of materials: increasing their electrical-to-optical power conversion efficiency, and increasing their range of emitted colors. And, where possible, we will try to connect these challenges to fundamental physical properties, including: high piezoelectric coefficients, high dopant and exciton ionization energies, high microscopic internal strain and chemical immiscibility, and large differences between the bond strengths of the product materials and the chemical precursors used to grow them. @FootnoteText@@footnote 1@J.Y. Tsao, Ed., "Light Emitting Diodes (LEDs) for General Illumination Update 2002" (Optoelectronics Industry Development Association, Washington D.C., 2002); A. Zukauskas, M.S. Shur, and R. Caska, "Introduction to Solid-State Lighting" (Wiley and Sons, New York, 2002); and M.R. Krames, H. Amano, J.J. Brown, and P.L. Heremans, Eds., Special Issue on High-Efficiency Light-Emitting Diodes, IEEE Journal of Selected Topics in Quantum Electronics, Vol. 8, Issue 2 (Mar-Apr 2002).

2:40pm **EM+SC+OF-WeA3 Organic Light Emitting Diodes as a Source of Light for General Illumination***, M. Stolka,* Consultant **INVITED**

Organic Light Emitting Diodes (OLEDs) have a potential to become a technology of choice for general illumination of commercial and residential buildings. There exist no fundamental obstacles to achieve the required power efficiency (>>100 lm/W), lifetime (>50,000 hrs), and the quality of emitted white light with high rendition index. OLEDs will be ten times more energy efficient as incandescent, and twice as efficient as fluorescent lamps. Recent discovery that triplet excitons can be harvested to produce photons with nearly 100% internal quantum efficiency represents a major breakthrough towards achieving the goal. Based on a spin statistics, only 25% of excitons are singlets, which were thought to be the only excitons capable of relaxing the energy as photons, by fluorescence. The remaining 75% of the excitons in triplet states were considered ineffective since the energy, gained by recombination of charges, is typically dissipated as heat. This was thought to impose a 25% fundamental limit on the internal quantum efficiency of photon generation. It was found that phosphorescent emitters, such as complexes of Pt or Ir, enable the utilization of triplet excitons as sources of photons as well. High energy efficiency, flexibility, conformability to any shape and form, light weight, distributed nature of the light sources, and the ability to emit any color including white are the main attractive features of OLEDs. However, significant challenges still remain. The outcoupling efficiency has to be increased beyond the current ~20%. The stability, especially of blue emitters, has to be improved. Better protection against the access of moisture has to be found, etc., etc. Strategies for increasing the power efficiency, increasing the lifetime of OLEDs, and methods of obtaining white light will be discussed.

3:20pm **EM+SC+OF-WeA5 Future Issues in Spintronics***, M.E. Flatté,* University of Iowa **INVITED**

Metallic spintronics, the control of electrical signals through the flow of spin-polarized current, has progressed from a research discovery in 1988 to a key information technology and commercial success. Almost every computer now contains at least one spintronic device - such as the read head for a hard disk drive. Encouraged by this success researchers have explored other material systems, especially those of semiconductors. New possibilities available from semiconductor spintronics include high-speed coupling of spin dynamics to light (optospintronics), nonlinear transport and gain (spin transistors), exceptionally long spin coherence times, and electrical control of ferromagnetism. Progress in these areas has been rapid, and has led to new perspectives on the optical and electrical manipulation or detection of information stored in magnetic systems. Quick summary examples of such new physical and material functionality within semiconductors will be shown. Semiconductor spintronics, however, cannot do without metallic magnetism, for metals provide an exceptional combination of high conductivity and high Curie temperatures. New spintronic devices probably will depend on hybrid structures, where each component is chosen for optimal properties from metallic, inorganic semiconducting, and organic semiconducting materials.

4:00pm **EM+SC+OF-WeA7 Growth and Applications of Epitaxial Metal-semiconductor Nanocomposite Structures***, **A.C. Gossard**, M. Hanson, D. Driscoll,* University of California, Santa Barbara **INVITED**

We explore the growth and ovegrowth of nanoscale semi-metallic islands in GaAs-based semiconductors. MBE-grown ErAs and ErSb islands grow epitaxially and coherently on the semiconductor surfaces with particle dimensions that are controlled by the deposition growth parameters. The islands can be overgrown with epitaxial semiconductors, and further layers of islands and semiconductor films can be grown to form superlattices of layers of metallic islands. The distribution of islands governs the electrical and optical properties of the nanocomposites, including Fermi level position, carrier mobility, photocarrier lifetimes, plasma properties, barrier formation and carrier tunneling.

4:40pm **EM+SC+OF-WeA9 Electronic Devices from Single Crystal CVD Diamond***, **J. Isberg**,* Uppsala University, Sweden*; D.J. Twitchen, G.A. Scarsbrook, A.J. Whitehead, S.E. Coe,* Element Six Ltd., UK **INVITED**

Diamond is well known as being the hardest of all materials making it useful in various mechanical applications. Perhaps less well known are the extreme electronic and thermal properties of diamond, which have raised considerable speculation over its usefulness as a semiconductor material in a number of applications. The high charge-carrier mobilities, dielectric breakdown field strength and thermal conductivity of high purity diamond makes it especially well suited in devices where high frequencies are required in combination with high power, high temperatures, or high voltages. Nevertheless, despite more than two decades of research, the breakthrough of diamond-based electronics has not yet happened, largely due to the difficulty of synthesising free-standing, high-quality, single crystal diamond. We will describe recent advances in growing single crystal intrinsic and boron doped diamond intended for electronic applications. The material was grown under conditions of extreme purity, resulting in films of exceptionally low defect densities. In the intrinsic material we have measured room temperature drift mobilities of 4500 cm@super 2@/Vs for electrons and 3800 cm@super 2@/Vs for holes. These mobility values were determined by using the time-of-flight technique on thick intrinsic diamond plates. The high values for the electron and hole mobility, as well as a measured carrier lifetime in excess of 2 @mu@s, indicates a huge improvement in the electronic quality of free-standing, single crystal chemical vapor deposited (CVD) diamond. At present commercially available electronic applications of diamond include UV and radiation detectors, X-ray dosimeters, photoconductive switches and surface acoustic wave (SAW) filters. These applications are mainly based on undoped diamond. We argue that even the lack of a shallow n-type dopant does not stop diamond from having an impact in high power and high frequency electronics because effective unipolar devices such as schottky diodes and MESFETs can be made. Many difficulties concerning the fabrication of diamond devices remain to be solved and a number of process technologies need to be developed such as reliable ion-implantation, etching, annealing, surface termination and contact fabrication technologies. However, the improvement in the electronic quality of diamond indicate that the potential of single crystal CVD diamond as a wide bandgap semiconductor is substantial and will eventually allow the expansion of the boundaries of device technology. @FootnoteText@ J. Isberg et al., Science, 6 Sept, 297 (2002) p1670.

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