Thin Films
Room 329 - Session TF-TuM
Thin Films on Organic, Polymeric and Biological Substrates

Moderator: G.N. Parsons, North Carolina State University

8:20am **TF-TuM1 Low Cost Thin Film Electronics on Flexible Polymeric Substrates*, T.N. Jackson,*** Penn State University **INVITED**

Silicon microelectronics has been spectacularly successful at providing increasingly complex digital processing and large-capacity digital memory with continually improving performance/$. It has been less successful at providing simple function at very low cost and in providing electronic function over large areas or on arbitrary surfaces. Thin film transistors (TFTs), based on either inorganic or organic semiconductors, are of interest for lowcost flexible and arbitrary substrate applications. Inorganic amorphous silicon (a-Si:H) TFTs are widely used as pixel access devices in displays and large area sensors on glass substrates. It is also possible to fabricate these devices on polymeric or other unconventional substrates and we have demonstrated a-Si:H TFTs on high temperature polymeric substrates (for example, polyimide) with performance very similar to that obtained on glass substrates. Organic semiconductors are of particular interest because they can be deposited and processed at very low temperature (often less than 100°C). Organic thin film transistor (OTFT) device performance now rivals or exceeds that of a-Si:H devices, and low OTFT process temperatures allow fabrication on a range of surfaces including cloth, paper, or polymeric substrates. Using small molecule organic semiconductors we have fabricated TFTs with field effect mobility > 1 cm2/V-sec on flexible polymeric substrates with good uniformity and yield. Devices of either type (organic or inorganic) are of particular interest for applications where their switch characteristics can be used for selection or isolation of arrays of devices. This approach, widely used for display addressing, allows many thousands or even millions of sensor, actuator, or other elements to be controlled with simple, low-cost electronics and the flexible processing used for thin film active devices allows direct integration with a wide range of materials and devices.

9:00am **TF-TuM3 Ultra-high Barrier Coating Deposition on Polycarbonate Substrates*, M. Schaepkens,*** *K.W. Flanagan, T.-W. Kim, M. Yan, A.G. Erlat, C. Heller, P.A. McConnelee,* General Electric

The use of polycarbonate film substrates enables fabrication of new applications, such as flexible display devices, lighting devices, and other flexible electro-optical devices, using low cost, roll-to-roll fabrication technologies. One of the limitations of bare polycarbonate material in these applications is that oxygen and moisture rapidly diffuse through the material and subsequently degrade the electro-optical devices. This paper summarizes recent results obtained at GE Global Research to solve the oxygen and moisture diffusion issue. It will be shown that through the application of thin, dense, plasma-based inorganic coatings one can significantly reduce the oxygen and moisture permeation rate through polycarbonate films. However, as a result of defects that are commonly present in these inorganic coatings there is a limit to the performance of such barrier coatings. To further improve the barrier performance, advanced barrier coatings comprising both inorganic and organic materials have been developed. Both modelling and experimental results will be presented that explain why these hybrid material barrier coatings are capable of reaching ultra-high barrier performance.

9:20am **TF-TuM4 Organic Thin Film Transistors based on Fluorene-Arylene Copolymers for Printed Electronics*, M.G. Dibbs*,** *P. Townsend, D. Brennan, S. Kisting, J. Shaw,* The Dow Chemical Company **INVITED**

During the last 50 years polymeric materials have played an important role in semiconductor fabrication, interconnect, packaging and displays. They have usually played a passive role and have not been involved in the active generation, amplification, and switching of current or voltage. This is now changing. Research efforts on polyanalines, conjugated thiophene oligomers and polymers and pentacene and thiophene oligimers have led to improvements of mobility by 5 orders of magnitude over the last 15 years. Polymeric semiconductors offer a means to create unique, low cost electronic devices since they can be readily fabricated into thin, mechanically robust films onto a variety of substrates by low cost processing techniques. Recently new generations of polymeric semiconductors have been developed. All plastic chips based entirely on organic materials have been demonstrated. Materials based on fluorene-arylene copolymers are under development for this purpose. This paper describes recent work with this family of materials, compares results obtained by different research groups, and discusses issues related to the interplay of device construction and material characterization with a focus toward printed electronics.

10:00am **TF-TuM6 Elastic Metal Interconnects*, J.E. Jones*,** *S.P. Lacour, S. Wagner, Z. Suo,* Princeton University

Stretchable, elastic metal interconnects are a key to the fabrication of 3-D conformal circuits and electrotextiles. The basic concept for reversibly stretchable, elastic metallization is a corrugated stripe of thin-film metal that is expanded by stretching. The maximum elongation is reached when the stripe is stretched flat. We prepared wavy metal stripes by evaporating gold onto pre-stretched strips of the elastomer, poly-dimethyl siloxane (PDMS). We experimented with gold metal line width and thickness and substrate elongation. We measured the film structure, amplitude, and wavelength, as well as electrical resistance in relaxed and various stretched states. So far we have reached elastic strains of 15% while maintaining the initial resistance and 80% with a rise in the resistance. We discovered a rich macroscopic and microscopic film morphology. Presented are the fabrication, electro-mechanical performance, and data on the film structure of these wavy metal interconnects.

10:20am **TF-TuM7 Properties of Indium Zinc Oxide Thin Films on Heat Withstanding Plastic Substrates*, H. Hara*,** *T. Hanada, T. Shiro, T. Yatabe,* Teijin Ltd., Japan

Accompanying with downsizing and improving of resolution of various display devices, a heat withstanding plastic substrates with low resistivity of transparent conductive oxide (TCO) films have been demanded. We succeeded in development of optical anisotropy transparent plastic substrates with high glass transition temperature over 200 degC. However, tin doped indium oxide (ITO) films used as the transparent conductive electrode have high resistivity about 5E-4 ohm cm because the deposition of ITO films was carried out by sputtering at room temperature to avoid the out gassing from the plastic substrate. This kind of ITO films arise the amorphous/crystal transformation (a/c transformation) at 150 degC. The a/c transformation makes the ITO films crack with increase in resistivity. Then, we have been investigated new transparent conductive oxide films with low resistivity for our heat tolerance plastic substrate. We found that 7.5 wt% ZnO doped indium oxide (IZO(7.5)) films are suitable for the plastic substrates by surveying the ZnO content preciously. IZO(7.5) films deposited at room temperature by conventional dc-magnetron sputtering exhibited the low resistivity, 2.9E-4 ohm cm, keeping the high transparency, over 86 %. By using XRD and TEM, it is revealed that IZO(7.5) films were remained the structure in amorphous after annealing. Moreover, the result of thermal properties of IZO(7.5) films by DSC was elucidated that the a/c transformation was occured at 350 degC. The etching rate to 3.5 wt% HCl of IZO(7.5) films were 2 nm/sec. It is almost as same as or quicker than that of amorphous ITO films. The durability to 5 wt% KOH solution is also good for practical use. We have already succeeded in deposition of IZO(7.5) film on our heat withstanding plastic substrate with 1000 mm width and 500 m length. This substrate with IZO(7.5) film can remain the all properties after 180 degC annealing.

10:40am **TF-TuM8 Interface and Bulk Charge in Low Temperature Silicon Nitride Dielectrics on Plastic Substrates*, K.J. Park*,** *G.N. Parsons,* North Carolina State University

Silicon nitride is a common gate dielectric for thin film transistors (TFT's) on plastic substrates, but the effect of processing temperature on charged defects in the film bulk and at the semiconductor/dielectric interface is not well known. For this work silicon nitride was deposited using various NH@sub3@/SiH@sub4@ gas ratios at temperatures between 50° and 300°C and the effect of process conditions on current vs. voltage (IV) and capacitance vs. voltage (CV) measurements was evaluated. For some conditions, CV was measured as a function of film thickness, and values for bulk and interface charge were extracted from the measured trends. We find that the apparent leakage current decreased with increasing NH/SiH ratio, but CV showed that increasing NH/SiH also leads in an increase in the flat band voltage shift, consistent with fixed charge in the films. Thickness dependence of CV indicates that increasing NH/SiH results in an increase in positive fixed charge at the interface, and an increase in negative fixed charge in the film bulk. When the NH/SiH ratio is fixed at 10, changing the substrate temperature from 50 to 250°C results in an increase in positive interface charge, and an increase in negative bulk charge, leading to charge compensation at higher temperatures. Internal charge can lead to a built in field which opposes the applied field, leading to a decrease in leakage current under high internal field conditions. Fixed charge is important to control threshold voltage and may affect transconductance in TFT devices. Results of amorphous silicon TFT's fabricated on polyimide substrates at various temperatures will be discussed.

11:40am **TF-TuM11 Effect of Swift Heavy Ions on the Structural and Optical Properties of RF Plasma Polymerized Aniline Thin Films**, *S. Saravanan, C. Joseph Mathai,* ***M.R. Anantharaman,*** Cochin University of Science and Technology, India*; S. Venkatachalam,* Vikram Sarabhai Space Centre, India*; D.K. Avasthi,* Nuclear Science Centre, India

Organic and polymer thin films have been receiving a great deal of attention due to their interesting properties. They find extensive applications in making devices such as Light Emitting Devices, rechargeable batteries, super capacitors, intermetallic dielectrics and EMI shielding. Polyaniline thin films prepared by plasma polymerization are cross-linked, pinhole free and their permittivity lie in the ultra low k regime. Electronic and photonic applications of polyaniline thin films attracted the attention of various researchers. Modification of polymer thin films by swift heavy ions is well established and ion irradiation of polymers can induce irreversible changes in their structural, electrical and optical properties. Polyaniline thin films prepared by RF plasma polymerization were irradiated with 92 MeV silicon ions for various fluences of 1 x 10@super 11@ ions/cm@super 2@, 1 x 10@super 12@ions/cm@super 2@ and 1 x 10@super 13@ ions/cm@super 2@ using the pelletron facility at Nuclear Science Centre, New Delhi, India. FTIR and UV Vis NIR measurements were carried out on the pristine and silicon ion irradiated polyaniline thin films for structural evaluation and optical bandgap determination. In this paper the effect of swift heavy ions on the structural and optical properties of plasma polymerised aniline thin film is investigated. Their properties are compared with that of the pristine sample. The FTIR spectrum indicates that the structure of the irradiated sample is altered. The optical bandgap of these irradiated thin film is considerably modified.

Author Index

Bold page numbers indicate presenter