

Congratulations to New ICFO PhD Graduate

Dr. Dhriti Sundar Ghosh graduated with a thesis on ultrathin metal transparent electrodes

October 16, 2012

Before starting work on his PhD, Dr. Dhriti Sundar Ghosh received a Master?s degree from the Indian Institute of Technology, Guwahati. During his PhD at ICFO, he worked on the development of indium-free transparent electrodes based on ultrathin metal films. In 2011, he was awarded the PhD Poster Award as well as the Photonics 21 Student innovation Award for his work on ultrathin metal films for energy-efficient photonics.

Dr. Ghosh presented a thesis titled 'Ultrathin metal transparent electrodes for the optoelectronics industry'. His thesis was supervised by ICFO group leader and ICREA Prof. Valerio Pruneri.

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ABSTRACT:

Transparent electrodes (TEs) are the essential elements of many optoelectronic devices such as solar cells, touch screens, organic LEDs, and LCDs. Consequently demand for TEs is growing very steeply and the market value presently stands at 8 billion USDs. The state-of-art indium tin oxide (ITO) has an excellent trade-off between optical transparency and electrical sheet resistance but suffers from several drawbacks, mainly the increasing cost due to indium shortage, and inadequate flexibility due to poor mechanical ductility. This thesis presents the development of a new class of TEs based on ultrathin metal films (UTMFs). The work started from understanding the fundamental aspects of UTMF growth and properties, and then focused on different UTMF based geometries, composition, and combination for potential applications in different optoelectronic applications. Single component ultrathin Ni and Cr films were shown to possess significantly high transparency in the ultraviolet (175-400 nm) and mid-infrared (2.5-25 \mu m) regions making them viable TE for devices such as UV photodiodes, and IR pyroelectric detectors. The natural oxidation process, which is a major concern for metal films, has been exploited to achieve stable metallic films by inducing a protective oxide layer. In another proposed novel design, incorporating an ad hoc conductive grid, the sheet resistance of UTMFs can be reduced by more than two orders of magnitude with negligible loss in transparency, which in turn eliminates the inverse trade-off relationship between optical transparency and electrical conductivity of continuous metal based TEs.A TE structure based on the ultrathin conductive Cu films with an application specific functionalized capping layer of Ti or Ni layer has been demonstrated. The properties of the TE can be tuned accordingly and show excellent stability against temperature, and oxidation. The suitability of Ag-Cu alloy films as TE as an alternative to ITO has been also investigated. The optical spectrum of such alloy films follows the average optical behavior of single component Cu and Ag layers, thus resulting in a much flatter optical response in the visible region. UTMFs combined with Al doped ZnO (AZO), which is possible ITO replacement, has also been demonstrated to show the possibility of hybridizing the two technologies. A bilayer Ag/AZO has been developed which can overcome the high reflection of metals and retain their good electrical behavior, while maintaining a minimum total film thickness. In another structure, UTMF capping layer were used to improve the stability of AZO. It was found that an ultrathin oxidized Ni capping layer with a thickness at percolation threshold greatly enhances the stability of AZO layer in harsh environment without affecting the electro-optical properties.

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