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Nano and micro-structured composite materials for privacy and smart window applications

Windows with controlled transparency are of increasing interest due to their potential energy saving and variable architectural view. These "smart windows", are a promising approach to reduce the energy consumption of buildings, which contributes up to 40% of the world's energy usage. There are several types of them, for example the ones which are voltage controlled such as the liquid crystalline based ones or the electrochromic materials usually control the transparency of the whole solar spectrum. However, thermochromic materials such as VO_2 based, they block a large fraction of the sunlight on hot days, while transmitting solar energy in cold weather. Thus through temperature or voltage responsive solar energy modulation, smart windows are a key component of green buildings that have been extensively studied in the recent years. During the last few years we have been studying several concepts to improve smart window functionality both using thermochromic VO_2 based nanostructures and recently based on liquid crystal line nanoporous micro-structure. In this talk we shall review our latest results along the following lines:Liquid crystalline new composite metamaterial made of nanoporous microparticles infiltrated with liquid crystal and controlled by temperature and voltage. VO_2 thermochromic nano-grid films with high luminous transmittance while maintaining the solar modulation ability. The perforated VO_2-based films employ orderly-patterned nano-holes, which can favorably transmit visible light dramatically but retain large solar modulation ability. SiO_2/VO_2 2D photonic crystals engineered for structural color tuning of reflected and transmitted light, while maintaining high solar modulation. Au/VO_2 half sphere core-shell structure as a case study of the temperature-dependent plasmonic effects and the thermochromic response for smart window applicaton. By varying the Au core size, we were able to tune the transition temperature of VO_2 shell. The analysis of the induced thermal strain at the Au/VO_2 interface shows that this could be the dominant reason for transition temperature reduction, contrary to the widespread view that plasmonic effects play the main role. Design rules for optimum performance of smart windows will be presented including a new approach based on deep learning.

Biography: Professor Ibrahim Abdulhalim is with the Electro-optics and Photonics Engineering Unit at Ben Gurion University since 2005. He worked in academic institutions and companies such as OCSC in UC at Boulder, the ORC at Southampton University, the Thin Films Center of the University of Western Scotland, in KLA-Tencor, Nova and GWS Photonics. His current research activities involve plasmonic and photonic biosensors, liquid crystal devices for imaging, biomedical imaging, optical metrology and energy devices. Published over 200 articles, 2 books, 10 chapters and inventor on 20 patents. He is a fellow of IoP and SPIE and an associate editor for the Journal of NanoPhotonics and for the Journal of Imaging. In 2014 he established Photonicsys Ltd., a company specialized in developing miniature plasmonic and photonic biosensor.

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