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Spectral response analysis of ZnO nanowire photoconductors and metal-oxide-semiconductor photodiodes

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ZnO nanowires (NWs) are promising structures for future nanoelectronics based systems due to their high mechanical resistance, strong piezoelectric properties and excellent electrical characteristics. Their high optical absorption at photon energies higher than the ZnO band gap (3.37 eV) and the intrinsic transparency of ZnO in the visible range make possible the fabrication of selective ultraviolet photodetectors with high visible rejection ratios. The operation of these devices is strongly influenced by the negative surface charge and the surface band bending which govern the electro-optical response in NW photoconductors. As NW photoconductors are typically built from the fabrication of metal-semiconductor ohmic contacts at both ends of the NW, the device current-voltage (IV) characteristic is linear and the resistance strictly depends on the NW diameter, the doping level and the surface band bending. In that scenario, ultraviolet light absorption gives rise to photo generated electron-hole pairs in the depletion region that are quickly separated by the transverse electric field. The photo generated holes drift towards the surface where they recombine with electrons trapped in surface acceptor levels. As a result, NW surface loses part of the negative charge at the expense of increasing the density of free carriers in the NW core. This mechanism reduces band bending and produces a sudden broadening of the conductive volume along the NW body that enhances the photo response, yielding photoconductive gains near 108 for nearly depleted NWs. In this work, we model the impact of those surface states on the spectral response of ZnO photoconductors and metal-oxide-semiconductor (MOS) photodiodes fabricated by dielectrophoresis. In particular, the study is focused on the response at photon energies below the bandgap energy where emission and capture processes via surface levels play a major role. The effect of surface passivation using SiOx dielectric deposited by electron cyclotron resonance chemical vapor deposition is also discussed. Potential applications of surface-assisted light absorption in very thin ZnO NWs are reviewed.

Biography

Jose Luis Pau is an Assistant Professor of Electronics at Universidad Autónoma de Madrid (UAM). He received a BS degree from UAM in 1998 and a PhD from Universidad Politécnica de Madrid in 2003. After Postdoctoral research with Prof. Elías Muñoz at ISOM, he received a Postdoctoral Fulbright Fellowship to join the Center for Quantum Devices at Northwestern University. In 2008, he also received a Ramon y Cajal Grant from the Spanish Ministry of Education and Science and became a member of the Applied Physics Department at UAM. His current research interests include synthesis, processing, characterization, and applications of semiconductor nanowires and 2D materials; light detectors and gas sensors. He has over 80 refereed publications, an H-index of 17 and his works have been cited more than 700 times.

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