Electrical & Computer ENGINEERING

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DSN-I Seminar Series

Professor Jon-Paul Maria

Dysprosium doped cadmium oxide: A gateway material for mid-infrared plasmonics

WHEN: November 7, 2014
WHERE: Scaife Hall 125
TIME: 3:30 p.m. - 5:00 p.m.

Abstract

The widespread interest in plasmonic technologies surrounds a wealth of emergent optoelectronic applications, such as plasmon lasers, transistors, sensors, and information storage. While materials for UV-VIS and near infrared wavelengths applications have been found, the mid-infrared range remains a formidable challenge to address: only a few known systems can achieve sub-wavelength optical confinement with low loss. Here, we undertake this challenge. A combination of experiments and ab-initio modeling demonstrate and understand an extreme peak of electron mobility in Dy-doped CdO that is achieved through “defect equilibrium engineering”. In so doing, we create a tunable plasmon host that satisfies the demanding criteria for mid-infrared spectrum plasmonics, and overcomes the losses seen in conventional plasmonic materials like Ag and Au. Extrinsic doping pins the CdO Fermi level above the conduction band minimum. It increases the formation energy of native oxygen vacancies, thus reducing their populations by several orders of magnitude. The substitutional lattice strain induced by Dy-doping is sufficiently small, allowing mobility values around 500 cm2/V•s for carrier densities above 1020/cm3. CdO:Dy resembles the ideal "lossless metal", a potentially new material for exploring integrated mid-IR plasmonic applications. Our claim is based on temperature dependent transport, mid-IR spectroscopy, thermal transport, and ab-initio characterizations showing that 1) CdO:Dy is a model system for intrinsic and extrinsic manipulation of defects affecting electrical, optical, and thermal properties; 2) oxide conductors so prepared are ideal candidates for plasmonic devices; and 3) the defect engineering approach for property optimization is generally applicable to other conducting metal oxides.

Speaker Bio

Jon-Paul Maria is a Professor of Materials Science and Engineering at North Carolina State University, and an NCSU University Faculty Scholar. Jon-Paul Graduated from The Pennsylvania State University with B.S., M.S., and Ph.D. degrees in Ceramic Science in 1994, 1996, and 1998, respectively. Jon-Paul and his research group specialize in novel materials development, synthesis, and integration science, with a general focus on electronic oxides. Jon-Paul currently directs or co-directs research programs on oxide-nitride heterostructures, Mid-IR plasmonic materials, ferroelectric thin films, nano-energetics, and radiation damage in electronic oxides. Research activities of note from the Maria Group include identification and exploration of novel high K gate dielectrics, developing novel approaches for thin film packaging, understanding scaling effects in ferroelectric thin films, and epitaxial integration of functional oxides with wide band gap semiconductors. Jon-Paul has been a member of the NCSU Materials Science and Engineering faculty for 12 years in that time, his research group graduated 13 Ph.D. students, 4 Masters, published ~200 manuscripts, and was awarded 13 patents. Jon-Paul received the NSF CAREER award, the IEEE/UFFC Young Investigator award, the NCSU Alcoa award, and the NCSU Alumni Outstanding Researcher award.

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