Project Title: "**RUI: Growth and Characterization of Epitaxial Zinc Oxide Films for Device Applications**," Proposal Number: DMR 1006083

NON-TECHNICAL DESCRIPTION

Zinc oxide (ZnO) is an attractive semiconductor material because of its unique characteristics, such as better electronic and optical properties, greater radiation hardness, relative ease of its synthesis, and greater environmental friendliness. It is therefore useful for the fabrication of solar cells, light emitters (e.g. light emitting diodes - LEDs and laser diodes), electronic devices for high power and high temperature applications, sensors and high-density data storage systems. Most of these applications require both n-type and p-type zinc oxide materials. While high quality n-type ZnO materials are readily available, it has proved difficult to develop p-type ZnO materials. This research will investigate the technique of delta-doping for the production of highly conductive p-type ZnO materials. This technique, which has proved successful with other semiconductor materials, involves confining p-type doping atoms in a narrow layer of the host ZnO material. With successful development of p-type ZnO materials, this project could make positive impact to the economic growth, energy savings, and environmental conservation efforts. This project will provide education and training of graduate and undergraduate students in semiconductor materials research using cutting-edge techniques that will prepare them for hi-tech careers or further graduate education, and will also be integrated with the Condensed Matter Physics course that attracts students from several science and engineering departments. Outreach to K-12 students as well as participation of YSU students from the under-represented groups (women, minorities) will be pursued.

TECHNICAL DESCRIPTION

While ZnO shares several electronic and optical properties with GaN, it has a higher exciton binding energy, greater radiation hardness, is available in bulk and requires simpler crystal growth and processing technology. These advantages make it uniquely attractive for fabricating various electronic, optical and spintronic devices. The presence of high intrinsic n-type impurity concentration however, has hindered achievement of good quality p-type ZnO materials necessary for device fabrication. The objective of this project is to achieve high conductivity p-type ZnO films using delta doping by magnetron sputter deposition. Delta doping has successfully yielded enhanced p-type doping in many wide band gap semiconductors with similar p-type doping challenges. The p-type doping atoms will be spatial confined in a narrow layer, resulting in a two-dimensional doping density profile with a unique V-shaped potential well, which exceeds the solubility limit of the commonly used homogeneous doping. This project could lead to transformational outcomes as it will not only impact semiconductor device development, but also permit investigation of the basic science related to the fundamental limits of doping profile miniaturization.