

## **NOVEL INTEGRATED PIEZOELECTRIC AND OPTOELECTRONIC DEVICES FOR COMMUNICATIONS AND WIRELESS SENSOR APPLICATIONS**

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Piezoelectric and optoelectronic devices have wide applications in communications systems. Applications of piezoelectric devices range from bulk crystal frequency references to surface acoustic wave filters and resonators, while optoelectronic devices such as lasers, photodetectors and modulators are critical components of free space and fiber optic communications systems. These devices have also found applications in wireless remote sensors. The first part of this talk is focused on ZnO based optoelectronic and piezoelectric devices for sensor applications. ZnO is an emerging wide bandgap semiconductor (3.32 eV at room temperature), and is also a well known piezoelectric material. The ZnO research at Rutgers pursued both optoelectronic and piezoelectric applications, culminating in integrated acousto-opto-electronic devices, the monolithically integrated tunable surface acoustic wave (MITSAW) device and the SAW UV photodetector. The principle of operation of these devices will be presented. These novel ZnO integrated SAW optoelectronic devices could be used as passive remote wireless sensors, voltage-controlled oscillators and chemical/biochemical sensors for gas-phase and liquid-phase sensing. Sensors based on ZnO thin film resonators on Si substrates, as well as LiNbO<sub>3</sub> SAW devices utilizing ZnO nanotip arrays for DNA and protein binding enhancement were also demonstrated. In the second part of this talk, InGaAs based eye-safe optoelectronic mixers for laser detector and ranging (LADAR) applications is presented. LADAR is the light based analog of radar, and is attractive for both military and civilian applications, such as collision avoidance, 3D terrain mapping, weapons fuzing, and facial recognition. The work presented here is based on InGaAs MSMs operating at 1.55  $\mu\text{m}$  wavelength for eye-safe LADAR applications, as well as novel symmetric-gain photodetectors being developed at UMaine. A summary of device level research will be presented, and applications of these devices to sensors and communications systems will be explored. The ZnO research at Rutgers was supported by the NSF (ECS-0088549, CCR-0103096, ECS-0224166), and by the NJ Commission on Science and Technology Excellence Center Program. LADAR research at UMaine is being supported by the US Army Research Office.

### **BIO SKETCH**

Nuri William Emanetoglu was born in Istanbul, Turkey, in 1973. He received his B.S. degree in electronics and communications engineering from Istanbul Technical University, Turkey, in 1995, and his M.S. and Ph.D. degrees in electrical and computer engineering from Rutgers University, New Brunswick, NJ in May 1998 and May 2003, respectively. He was a post-doctoral research associate at Rutgers University from May 2003 to December 2004, and an ORAU post-doctoral fellow at the Army Research Labs between January 2005 and December 2006. He has been at UMaine since January 2007. At Rutgers, Dr. Emanetoglu worked on the novel multifunctional wide bandgap semiconductor zinc oxide, ZnO, and its ternary magnesium zinc oxide, Mg<sub>x</sub>Zn<sub>1-x</sub>O. His work covered device design, analysis, fabrication and testing of piezoelectric (surface and bulk acoustic wave) and optoelectronic devices (photoconductive and photovoltaic UV detectors, Schottky diodes, MESFETs and MISFETs), ZnO based nanostructures and devices, and fabrication process development (photolithography, metallization, etching, ohmic and Schottky contacts). Dr. Emanetoglu's work at ARL covered device design, fabrication and testing of InGaAs based MSM optoelectronic mixers for LADAR applications. The work involved both the optoelectronics and RF circuits fields. Dr. Emanetoglu's work at UMaine covers sensors and optoelectronic devices and their system applications. Current projects include heterostructure phototransistors for LADARs, LADAR sensor systems, optoelectronic devices based on the AlN/InN heterostructure for 1.3  $\mu\text{m}$  and 1.55  $\mu\text{m}$  (telecomm) wavelengths, and surface acoustic wave sensors and filters. Dr. Emanetoglu has published 22 journal articles, 15 conference proceedings, one book chapter, and is a co-inventor of seven US patents. He is a Member of the IEEE. He received the second Best Student Award in the ACCG/east-97 Conference of the American Association for Crystal Growth, and Best Student Paper Award in Surface Acoustic Waves, IEEE 2001 International Ultrasonics Symposium, Atlanta, GA, October 2001.