Seminar MSc Course “Advanced Functional Materials”
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Challenges in the Growth of High Crystal Quality Cu_2O for the Observation of Giant Rydberg Excitons

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Abstract

Cuprous oxide (Cu_2O) is a p-type metal-oxide semiconductor that has a fundamental, direct energy bandgap of 2.1 eV. It has been suggested to be suitable as a solar cell absorber for a long time but so far device efficiencies have been limited to less than 10% [1]. Cu_2O has also been shown to be suitable for water splitting and CO_2 reduction. In addition, C*u*$_2$O is an archetype for the study of excitons that were observed for the first time in this novel p-type metal oxide semiconductor in 1956. Consequently, C*u*$_2$O is still an active topic of ongoing investigation that attracted even more attention after the observation of giant Rydberg excitons with principal quantum numbers up to n = 25 as well as exciton-polaritons in a $SiO_2/Ta_2O_5/Cu_2O/Ta_2O_5/SiO_2$ Fabry-Pérot cavity. However these giant Rydberg excitons and polaritons have only been observed in superior naturally occurring crystals of C*u*$_2$O so further efforts into the growth of high crystal quality and purity C*u*$_2$O are required which is important from a fundamental but also technological point of view. In this talk I will describe our activities and the challenges involved in the growth of C*u*$_2$O by thermal oxidation of Cu. The C*u*$_2$O we obtain is polycrystalline with a cubic crystal structure and consists of single crystal grains with mm sizes but Kirkendall voids form in the middle of the crystal due to the bifacial oxidation of Cu which may be removed by polishing or by reducing the thickness s of the Cu. The C*u*$_2$O exhibits clean photoluminescence at 2.1 eV in excellent agreement with density function theory calculations of the electronic band structure and is currently being optimized to observe large Rydberg excitons with principal quantum numbers of n larger than 10.

Short CV

M. Zervos has a broad range of expertise covering synthesis, electrical, structural and optical characterization of semiconductor materials, device processing including optical and electron beam lithography and computational semiconductor physics. M.Zervos joined the University of Cyprus in August 2006 and set up the Nanostructured Materials and Devices Laboratory in May 2008 for the growth of semiconductor nanowires and the study of their fundamental properties for energy related device applications.

He currently teaches (a) Mechatronics and (b) Introduction to Nanoscale Science and Nanotechnology as part of the undergraduate curriculum and (c) semiconductor physics to postgraduates undertaking research in the materials science group of the department but also for postgraduates from other departments e.g. electrical engineering and physics.