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MBE growth and structural and electrochemical characterization of indium tin oxide and tin oxide nanoparticles grown on silicon

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Indium tin oxide (ITO) and tin oxide (TO) have been extensively investigated for various applications such as transparent transistors[1], touch panels[2] and back contacts for solar cells[3]. There has been considerable recent interest in investigating the growth and physical properties of ITO and TO, using solution techniques based on sol-gel or solvothermal processing[4], chemical vapor deposition[5] and thermal beam evaporation[6]. Due to their nature, these methods provide very limited control over orientation of the structures formed and in the consistency across a deposit. Molecular beam epitaxy (MBE) offers considerable improvements in crystalline control and interfacial quality of deposited structures on a range of substrates.

The recent demonstration[7] of a transparent lithium ion battery has shown potential scope for development of see-through charge storage materials, where touch screens, solar cells and batteries can coexist with transparent, or optically addressable form. Tin oxide is particularly promising material for this application, due to its large theoretical lithium storage capacity as well as high rate capability[8].

Here, we present unique core-shell superstructures of tin oxide nanoparticles and single crystalline indium tin oxide nanoparticles prepared by MBE at elevated temperature. We demonstrate excellent antireflection and broadband transparency of the deposited nanoparticles without sacrificing electrical conductivity. These nanomaterials also reversibly alloy with lithium and behave as rechargeable Li-ion battery anodes. A degree of buffering for volumetric expansion and pulverization is provided by a co-insertion effect of lithium into the underlying silicon. This work also details the specific structural changes occurring in single-crystal ITO and TO nanoparticles deposited on substrate during lithium insertion.

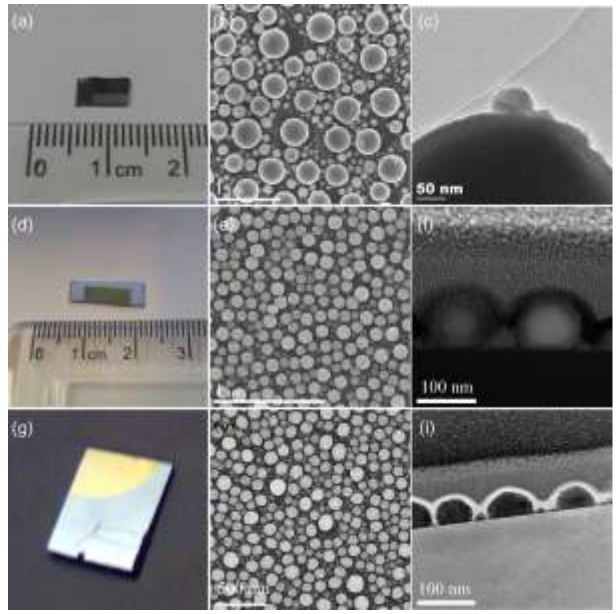

Fig. 1. Optical, SEM and TEM images for (a-f) tin oxide nanoparticles. (g-i) Indium tin oxide nanoparticles.

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