PLENARY LECTURE

ENERGY: ONE OF THE BIGGEST CHALLENGES IN 21ST CENTURY

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It is not sustainable for human kind to produce close to 80% of energy needs by burning fossile fuels (dominant in global primary energy production) mainly due to the detrimental effect of increasing CO_2 emission into atmosphere, causing global warming and catastrophic climate changes on one hand (global temperature rise, warming oceans, shrinking ice sheets, glacial retreat, see level rise,...) as well as adverse effects on human health on the other. In order to solve many problems we are facing as humanity, such as poverty, infectious diseases, drinking water, etc., a reliable, affordable and more equally and fairly distributed energy supply is needed. An ever-increasing demand for energy (mostly for heat, electricity, and transport fuels) by a growing population, which will approach the 10 billion mark by the middle of 21st century, out of which 80% will live in urban areas, requires building more than double of the existing installed capacities for energy production, currently at 19 terawatts. All of this indicates that meeting the demands for sufficient supply of affordable and reliable energy that has a minimal impact on the environment, will be one of the biggest challenges facing humanity in 21st century. This requires opening and exploring many different avenues of research and development, including scavenging of heat, lost during energy production and conversion processes. One of such avenues is the field of thermoelectric materials, which demonstrate energy harvesting based on Seebeck effect i.e. the conversion of the temperature gradient into electric power, with potential applications in sensors, consumer electronics, medical devices, etc. Thermoelectric $M_2O_3(ZnO)_n$ nanowires, where M could be In, Ga, Fe, synthesized using facile solid-state diffusion, enabled us to control their defect structure at atomic level. Two kinds of defects, planar, parallel to basal wutzite planes, and zigzag, parallel to pyramidal planes, facilitate decoupling of electrical and thermal properties through quantum confinement effects and control of phonon scattering. Both of these factors facilitate achieving a high figure of merit, ZT ($ZT=\sigma \cdot S^2 \cdot T/k$, where σ, S, T, and k represent electrical conductivity, the Seebeck coefficient, absolute temperature and thermal conductivity, respectively), used to rank thermoelectric materials. High angle annular dark field (HAADF) imaging of these nanowires revealed the presence of planar defects - monoatomic layers of indium perpendicular to the [001] direction, separated by wurtzite $MZn_nO_{(n+1)}^+$ slabs of various thicknesses at nanoscale. Incomplete In/Ga monoatomic layers were observed as well. The ends of these incomplete layers are associated with edge dislocations, providing fast diffusion paths for large indium and gallium atoms. In summary, $M_2O_3(ZnO)_n$ polytypoid nanowires were converted from pure ZnO nanowires using a simple preferential diffusion process along line defects, which can be used to produce a wide range of ZnO alloys with controllable alloy concentration and layer density. From this study it is apparent that better control of atomic scale features could be the key in developing next-generation thermoelectric materials.