Zinc Oxide-Capped Carbon Nanoforest: Novel Method of Defects Engineering via Focused-Laser-Beam Modification

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As a wide-bandgap semiconductor, zinc oxide (ZnO) is prone to having multiple native defects introduced into its bandgap. This high defect density is oft-deemed undesirable as it hinders the synthesis of p-type ZnO which has useful electronic applications. Also problematic is the inability to control defect formation via current synthesis methods, which leads to the unpredictable performance of ZnO-based devices. However, recognising that these defects account for certain valuable optical and electrical properties of ZnO, we experimented with a novel approach of defect-introduction via focused-laser-beam (FLB) modification in a bid to control defect formation. Our approach included the incorporation of a multiwalled-carbon-nanotube (MWCNT) array beneath the ZnO layer to enhance energy absorption, forming a ZnO-MWCNT nanohybrid. FLB modification enabled us to achieve site-selectivity, and by simply adjusting the laser power, we could tune the type and concentration of defects formed. Generating a higher defect density not only increased the intensity of the fluorescence emitted by ZnO under ultraviolet (UV) excitation, but also enhanced its field emission properties. In particular, the turn-on electric field (ETO) of the nanohybrid decreased. A lower ETO reduces the probability of arc formation, a significant problem currently undermining the industrial feasibility of field emission displays (FED). However, these improvements came at the expense of current stability at too high a laser power. Interestingly, we observed a Goldilocks phenomenon: by using a moderately-high laser power, we could strike a balance between ETO and current stability, creating a field emitter that has great potential for industrial use.

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