Nano-hetero-architectures: prominent field electron emitters for displays

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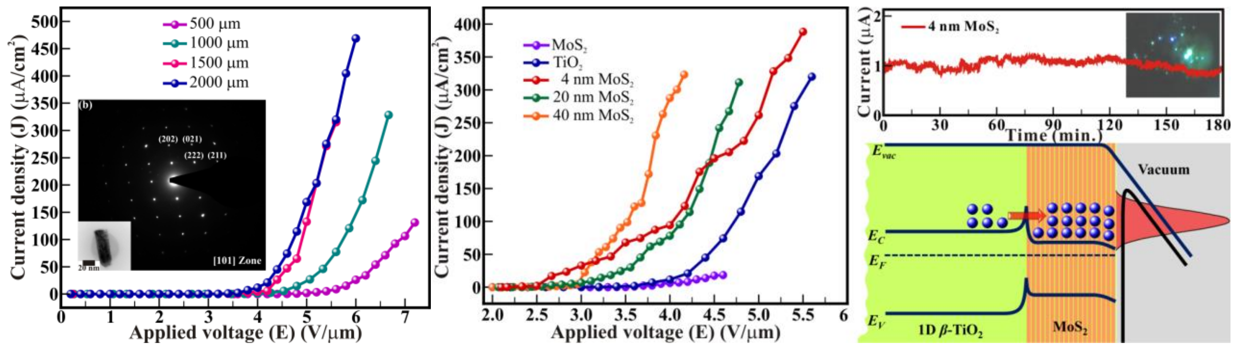

The high aspect ratio and sharp tip features of one-dimensional (1D) metal oxide nanostructures have engaged most of the researchers to explore their electronic/physical properties for the development of efficient functional devices for energy conversion and conservation. TiO_2 is one of them but explored to a certain extent for field-emission displays despite its low work function of 3.9 to 4.5 eV. Moreover, the synthesis of pure brookite (β) phase is always challenging due to its metastable nature and commonly accompanied with the anatase and/or rutile phases. That is why numerous scientific reports are found on the utilization of rutile and anatase phases for a variety of applications including field emitters. High-temperature calcination and annealing processes were unsuccessful in yielding pure β phase. Considering the thermodynamic stability of β phase at dimensions between 11-35 nm, we have synthesized 1D β-TiO_2 nanorods utilizing HFMOV (lab designed) technique. Furthermore, 2D MoS_2 layers/shells of desired thicknesses were grown over β-TiO_2 nanorods using the Pulsed Laser Deposition (PLD) technique. The turn-on field of 3.9 V/μm required to draw current density of 10 $\mu A/cm^2$ from pure 1D β-TiO_2 nanorods (Left panel) was considerably reduced further to 2.5 V/μm by forming the 4 nm MoS_2 shell/layers over it (Middle panel), which is significantly lower than the doped/undoped 1D TiO_2 nanostructures, pristine MoS_2 sheets, MoS_2@SnO_2, and TiO_2@MoS_2 heterostructure based field emitters. Furthermore, these MoS_2@TiO_2/Si emitters exhibit better emission stability (Right upper panel). The over-layer of conducting MoS_2 along the β-TiO_2 nanorods induces most of the injected electrons to transport easily toward emission sites, and enhances the effective field at its top and leads for the stable and enhanced FE (Right lower panel). The results obtained suggest that the MoS_2@β-TiO_2 nanorods hetero-architecture holds the potential for applications in FE based nanoelectronic devices like displays and electron sources. Moreover, the strategy employed here to enhance the FE behavior via rational design of hetero-architecture structure can be further extended to improve other functionalities of various nanomaterials. The complete article is accessible at http://pubs.acs.org/doi/abs/10.1021/acsomega.7b00345