Tata Institute of Fundamental Research
Survey No. 36/P, Gopanpally Village, Serilingampally, Ranga Reddy Dist., Hyderabad - 500107

Webinar

Studies on the Vapour Transport Assisted Growth of Two-Dimensional Atomic Layers and Their Heterostructures for Opto-Electronic Devices and Catalysis

Rahul Sharma

TCIS, Hyderabad

Moore's law predicted that the number of transistors on a silicon chip doubles every year, and semiconductor technology has followed this pattern for a long-period of time. Now, the silicon based semiconductor technology has reached a limit where the electron flow through nanometer-thick silicon channels becomes difficult to control. Three-dimensional (3D) structure of such crystals having imperfections can cause significant scattering to the electrons while flowing through their thin channels, and hence becoming difficult to control the electron flow via an external gating. Two-dimensional (2D) crystalline structure of atomic layers having quantum confinement effects have potential in this scenario and especially, semiconducting transition metal dichalcogenides (TMDs) are identified as potential candidates in nano-electronics, addressing those above-mentioned issues related to the 3D semiconductors. The TMDs with Sulphur (S) and Selenium (Se) as chalcogen possess high band gaps and heavy effective carrier mass, which lead to possibilities of developing FETs having small channel widths, but such 2D materials have limitations in terms of their large area uniform growth, chemical stability, and scalability. In this work, we tried to address some of these issues related to the TMD growth, band engineering, and their stability for applications in electronics and catalysis. We identified a catalysis free growth for a stable and scalable 2D material known as fluorographene (FG), and explored its transfer free growth over TMDs. The heterostructure of these two layers are found to be functioning as a high performing ultra-stable active channel for a wide wavelength phototransistor. Furthermore, we explored the methods for tuning the physical and chemical properties of the TMDs by doping them with different chalcogens and transition metals. Atomic doping leads to the changes in the band gap of the host TMD where it can behave as a different chemical entity. The possible defects in these alloys are also identified using high resolution electron microscopy and low temperature photoluminescence (PL) studies. We have identified that these atomic alloys can be morphologically controlled during their growth and it results in to a significant enhancement in their electrocatalytic activities.

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