2-dimensional layered Quantum Materials: From Growth to Opto-electronic Transport

Bubunu Biswal, Ramesh Rajarapu, Prahald Kanti Barman, Renu Yadav, Saroj Poudyal, Abhishek Misra*

Centre for 2D Materials research and Innovations, Department of Physics

Indian Institute of Technology Madras, Chennai, India. 600036

Layered 2-dimensional (2D) transition metal dichalcogenides (TMDCs), through different polymorphic phases and broad range of bandgaps, provide a rich landscape to study range of physical phenomena occurring at atomically thin dimensions. In order to access the novel topological nontrivial phases through quantum transport measurements, it is inevitable to have high quality materials of semiconducting and metallic nature and make high quality electrical contacts. Among the 2D TMDCs, 1T-$PtSe_2$, 1T′-$MoTe_2$, T_d-WTe_2 etc. show semimetallic behaviour and can be used as electrodes forming high quality, smooth, dangling bond free interface with 2D semiconductor channel. For a metallic electrode, its work function is a crucial parameter to decide the carrier flow across the interface. In this direction, we have evaluated the work function of 1T-$PtSe_2$, 1T′-$MoTe_2$, T_d-WTe_2 using the metal-oxide-semiconductor capacitor device structures. For semiconductors, we have developed a novel phase selective growth methodology to grow rhombohedral(R)-phase MoS_2 having sword like geometry with lengths up to 100 µm and uniform width and thickness. The grown MoS_2 shows good electrical properties with a mobility of 40 cm^2/V-s, I_{on}/I_{off} ratio of ~10^6 and high value of degree of circular polarization ~58% at 100 K temperature. The second harmonic spectroscopy shows the non-linearity of the R-phase irrespective of even and odd number of layers which is in contrast to H-phase MoS_2. These findings are significant for the development of future quantum devices based on ultrathin layered materials.

Mr. Bubunu Biswal