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2D Crystal heterostructures properties and growth by molecular beam epitaxy[1]

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Two-dimensional (2D) crystals such as transition metal dichalcogenides (TMDs) along with other families of layered materials including graphene, $SnSe_2$, GaSe, BN etc, has attracted intense attention from the scientific community. One monolayer of such materials represent the thinnest "quantum wells". These layered materials typically possess an in-plane hexagonal crystal structure, and can be stacked together by interlayer van der Waals interactions. Therefore, it is possible to create novel heterostructures by stacking materials with large lattice mismatches and different properties, for instance, superconductors ($NbSe_2$), metals, semi-metals (graphene), semiconductors (MoS_2) and insulators (BN). Numerous novel material properties and device concepts have been discovered, proposed and demonstrated lately. However, the low internal photoluminescence efficiency (IPE, $<1\%$) and low carrier mobility observed in the 2D semiconductors suggest strongly that the materials under investigation today most likely suffer from a high concentration of defects. In this talk, I will share our progress and the challenges we face in terms of preparing, characterizing these 2D crystals as well as pursuing their applications.

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