Two-dimensional (2D) layered MoS$_2$ layers have exhibited a large set of unusual and superior material properties unattainable in any traditional bulk materials, drawing significant research interests nowadays. For instance, they present superior semiconducting properties accompanying high carrier mobility and large current ON/OFF ratio as well as extremely large in-plane strain limit and thickness, projecting high suitability for emerging flexible and stretchable electronics. Such properties and applications strongly depend on the physical orientation and chemical composition of constituent 2D layers. 2D MoS$_2$ layers can be chemically grown in two distinct orientation, e.g. horizontal alignment for electronics and optoelectronics, and vertical alignment for electrochemical and sensing applications. Moreover, 2D heterostructure layers composed of vertically stacked dissimilar 2D TMDs held via weak van der Waals (vdW) attractions offer unique 2D/2D interfaces, envisioned to display exotic material properties, unattainable in their monocomponent counterparts. However, the underlying principle of their layer orientation-controlled growth and integrations are not well suited for scalable production, leaving their projected technological opportunities far from being realized for various novel applications.

Herein, we study various aspects of 2D MoS$_2$ layers from their large-area layer-orientation controlled growth and heterostructures integration to applications in stretchable electronic devices. We developed a chemical vapor deposition (CVD) synthesis which can grow large-area (> cm$^2$) 2D MoS$_2$ layers in a layer-controlled manner and investigated their underlying growth mechanism. We then developed a viable transfer approach of the as-grown 2D layers and integrate them into secondary target substrates to realize a new type of 2D MoS$_2$-layers based heterostructures. To extend their layer-controlled CVD growth and integration approach, a high-performance stretchable 2D MoS$_2$-based electrical sensors were demonstrated on the elastomeric substrates with unconventional structural layouts. This study paves the way to explore this emerging atomically-thin material in realizing a wide range of unconventional device and technologies which have been foreseen to be impossible otherwise.

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The public is welcome to attend.