3D and 2D TMD's using CVD synthesis

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Abstract

Layered transition metal chalcogenides (TMDs) ((MX_2) (M=Mo or W; X=S, Se, Te)) are a versatile class of materials which have attracted significant interest recently owing to their distinctive properties that can complement graphene and promise potential application in diverse fields such as optoelectronics, spintonics, solid lubricants, energy storage, industrial catalysts, etc. TMD's were shown to form closed caged polyhedral and cylindrical nanostructures, namely inorganic fullerene-like (IF) materials or inorganic nanotubes (IN), analogous to carbon nanotubes and fullerenes almost two decades ago.[1] Recently inorganic graphene analogous (IGA) have come in demand while exploring two dimensional (2D) materials beyond graphene[2]. Even though 2D TMDs can be synthesized by various top down and bottom up approaches[3], chemical vapor deposition (CVD) offers the most promising prospect for producing large area reproducible crystalline layers/films[4]. However, the properties of these layered chalcogenides are highly dependent upon their structure and hence the method of preparation must be carefully selected to deliver a product tailored to the application requirements.

In this work we report a fast, facile and catalyst free chemical vapor deposition technique for the controlled synthesis of different well-defined tungsten disulphide (WS_2) nanostructures (3D, 2D) selectively using similar synthesis strategy. Two distinct morphologies of WS_2 have been synthesized, namely nanoflowers[5] (3D) and nanosheets or thin films (2D), by varying few critical parameters such as the ratio of the precursors, temperature and synthesis time in the CVD process. The presence of large number of edge sites in 3D nanoflowers (average size 1 micrometer) with few layer (6-8) petals of lateral dimensions 500 nm are favorable for catalysis. The large area 2D WS_2 with lateral dimensions of tens of micrometers formed by collating triangular domains of roughly 5-10 micrometer and thickness of 4-6 nm (few layers) show promise for optoelectronic device application. The thickness can be further reduced to monolayer films by reducing the pressure in CVD system. The ability to tailor the as-produced material, from 3D to 2D nanostructures, by controlling few specific parameters we have identified product selectivity. This method offers excellent scale-up possibilities and great versatility, allowing tailoring and structural control of different WS_2 morphologies and properties customized to demand.

References

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[5] A. Prabakaran et al., Chemical Communications, **50**, (2014) 12360-1236.

Figures

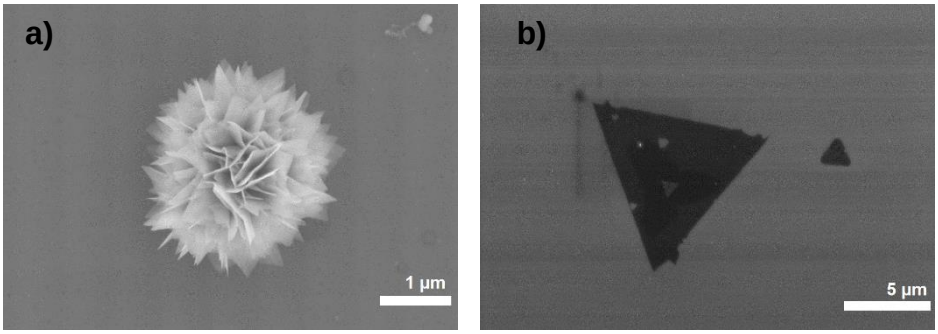

Figure 1: **a)** SEM image of WS_2 nanoflowers **(3D) b)** SEM image of WS_2 nanosheet **(2D)**