Plasma-enhanced atomic layer deposition of two-dimensional transition metal dichalcogenides for nanoelectronics

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Abstract: This presentation will highlight our recent progress on the large-area synthesis of two-dimensional transition metal chalcogenides for nanoelectronics using advanced plasma-enhanced atomic layer deposition cycle schemes.

2D materials have been the focus of intense research in the last decade due to their unique physical properties. This contribution will highlight our recent progress on the large-area synthesis of two-dimensional transition metal chalcogenides for nanoelectronics using advanced plasma enhanced atomic layer deposition cycle schemes. First, I will discuss how we can use advanced cycle schemes to deposit wafer-scale polycrystalline MoS_2 thin films at very low temperatures down to 100 °C. We have identified the critical role of hydrogen during the plasma step in controlling the composition and properties of molybdenum sulfide films. By increasing the H_2/H_2S ratio or adding an extra hydrogen plasma step to our ALD process, we can deposit pure polycrystalline MoS_2 films at temperatures as low as 100 °C. To the best of our knowledge, this represents the lowest temperature for crystalline MoS_2 films prepared by any chemical gas-phase method. [1, 2]

The dominant method for preparing MoS_2 via ALD is to alternately expose a substrate to a metalorganic precursor and a hydrogen sulfide (H_2S) or a plasma containing H_2S. H_2S is a corrosive, toxic, and flammable gas that is heavier than air, which makes it hazardous and expensive to store, install, and transport. Alternative sulfur precursors in the solid or liquid phase would be beneficial in terms of cost and safety and would require the installation of no additional hardware for most ALD reactors. In the second half of this contribution, the widely researched ALD process using bis(tert-butylimido)bis(dimethylamino)molybdenum(IV) ($(tBuN)_2(NMe_2)_2Mo$)) and H_2S plasma is compared to a novel ALD process using $(tBuN)_2(NMe_2)_2Mo$, hydrogen plasma, and di-tert-butyl disulfide (TBDS), which is an inexpensive, liquid-phase sulfur precursor. [3]

References

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