Ferecrystals based on Atomic Layer Deposition

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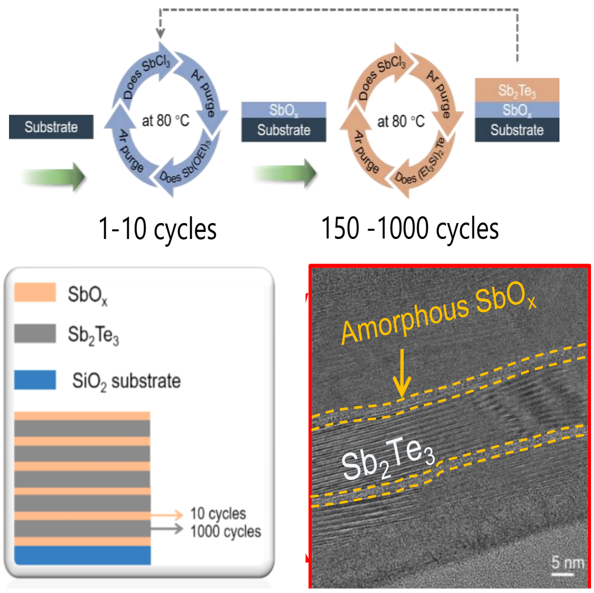
Atomic layer deposition is a very versatile technology for the deposition of thin films with precise thickness control on large areas, non-planar surfaces and 3D objects. The chemical reaction is surface limited, well defined and works in most cases at low temperatures (RT to 250 °C). For a number of classical van der Waals 2D materials, there have been reports on ALD of transition metal dichalcogenide (TMDC) of MoS_2, SnS_2, WS_2 and WSe_2, which also included the electronic characterization as a field effect transistor (FET).



In this work [1], we have fabricated by atomic layer deposition (ALD) multilayers of layered materials based on topological insulators and van der Waals materials, called *ferecrystals*. These ferecrystals can be tailored to exhibit unusual properties such as high electrical conductivity or low thermal conductivity or magnetic properties. A detailed ferecrystal study was performed on ferecrytals of Sb_2Te_3 and SbO_x, which has been grown at the same temperature as single layers of Sb_2Te_3. Without post-annealing, the electrical and thermoelectric characterisation of the highly ordered samples have been performed with the ZT-chip setup. In general, the carrier mobility is very high >150 Vs^2/cm^2 and is even improved when the thickness of the Sb_2Te_3 layers is reduced and the number of SbO_x layers (typically 2 nm thickness) is increased. Detailed XRD investigations have been performed and an enhanced crystalline order is observed in the ferecrystal system compared to individual layers of Sb_2Te_3. We have grown ferecrystals based on Sb_2Te_3 and Sb_2Se_3 with tetrahedral and orthorhombic crystal structure, respectively. The p-type hole carrier concentration of Sb_2Te_3 films can be enhanced through the sublayer doping of Sb_2Se_3. The highest carrier concentration achieved was 2.5×10^{19} cm^{-2} when the thickness ratio of Sb_2Te_3 to Sb_2Se_3 was (4 nm/2 nm). Further reduction of the Sb_2Te_3 thickness resulted in a high Seebeck coefficient of 172 µV/K at room temperature. In the presentation we will demonstrate further materials combinations of ferecrystals.

Reference

1. J. Yang, S. Mukherjee, S. Lehmann, F. Krahl, X. Wang, P. Potapov, A. Lubk, T. Ritschel, J. Geck, K. Nielsch, *Small* **19**, 2306350 (2023) **doi.org/10.1002/smll.202306350**