Atomic Layer Etching
Room Baekeland - Session ALE2-TuA

Novel ALE Techniques and Materials

Moderators: Satoshi Hamaguchi, Osaka University, Japan, Alok Ranjan, TEL Technology Center, America, LLC

4:30pm **ALE2-TuA-15 Novel Chemistries for Layer-by-Layer Etching of 2D Semiconductor Coatings and Organic-Inorganic Hybrid Materials***, **Anil U. Mane**, M Young, D Choudhury, S Letourneau, A Yanguas-Gil, J Elam,* Argonne National Laboratory **INVITED**

Here we report two new advances in atomic layer etching (ALEt) that extend our range of capabilities in nanoscale device fabrication. Semiconductor device manufacturing is limited by our ability to precisely deposit and remove thin film layers at the various levels of multistep device fabrication processes. Consequently, innovations in atomic layer deposition (ALD) and etching methods are essential. ALD-based methods have matured significantly and are now used extensively in semiconductor fabs. Recently, there has been an intense focus on developing ALEt methods. In particular, thermal ALEt has been shown to precisely remove ALD inorganic thin films selectively and on complex structures. These capabilities have opened new possibilities for nanoscale device design. Here, we report a new thermal etching process similar to ALEt for removing hybrid inorganic-organic layers that we call molecular layer etching (MLEt) [1]. This MLEt process uses vapor phase lithium organic salts in combination with trimethyl aluminum to perform layer-by-layer etching of molecular layer deposition (MLD) coatings. Ultra-thin layers of two dimensional (2D) transition metal dichalcogenide (TMD) semiconductors can exhibit exceptional electrical, optical, magnetic, mechanical and chemical properties. This allows the exploration of internal quantum degrees of freedom of electrons and their potential application in optoelectronic, energy, and sensor devices. Among the various 2D-TMDs, MoS_2 has shown exciting material properties and this has stimulated the exploration of a variety thin film synthesis methods such as physical vapor deposition (PVD), chemical vapor deposition (CVD), and solution based methods. In addition, the ALD community is investigating ALD methods for MoS_2 growth [2-3]. Here we report the thermal ALEt of ALD MoS_2 thin films [4]. We believe the successful combination of both ALD and ALEt of MoS_2 and other TMDs can pave the way to control the synthesis of 2D-TMD layers over large areas. Combining ALD and ALEt will allow MoS_2 interface engineering and enable MoS_2 integration into the large-scale manufacturing of future complex device structures.

[1] Molecular Layer Etching of Metalcone Films Using Lithium Organic Salts and Trimethylaluminum,

Young et. al., https://doi.org/10.1021/acs.chemmater.9b03627

[2] Atomic layer deposition of molybdenum disulfide films using MoF_6 and H_2S,

Mane et. al., https://doi.org/10.1116/1.5003423

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