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Editorial: 2022 retrospective: thin solid films

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Editorial on the Research Topic
2022 retrospective: thin solid films

As we delve into the realms of material science and nanotechnology, thin solid films stand as pivotal components shaping technological innovations across various domains. The year 2022 witnessed significant strides in understanding, manipulating, and harnessing the potential of thin solid films, offering profound insights and transformative applications.

The quest for enhanced functionality and performance drove relentless efforts in thin film deposition techniques. From chemical vapor deposition to physical vapor deposition and beyond, researchers explored novel methodologies to fabricate thin solid films with unprecedented precision, uniformity, and scalability. The convergence of experimental techniques and computational modeling empowered scientists to unravel the intricate dynamics governing thin film growth, epitaxy, and morphology evolution, paving the way for tailored material properties and device functionalities.

In this contest, the article titled "Novel Method for the Growth of Two-Dimensional Layered InSe Thin Films on Amorphous Substrate by Molecular Beam Epitaxy" by Sheng-Wei Hsiao and coworkers, introduces a groundbreaking approach to overcome challenges in growing two-dimensional (2D) single-phase indium selenide (InSe) thin films using molecular beam epitaxy (MBE), paving the way for the development of advanced 2D electronic devices.

While InSe holds potential for various electronic and optoelectronic applications, achieving a single-phase InSe thin film has been challenging due to the close formation energy between InSe and In_2Se_3.

This study presents a novel growth method involving the predeposition of indium on the substrate followed by InSe growth at elevated temperatures, effectively controlling stoichiometry and enabling high-quality growth even on amorphous substrates. Experimental results demonstrate the successful formation of the 2D InSe phase under both indium-rich and -poor conditions, with the predeposited indium precursor facilitating the transition to InSe while suppressing In_2Se_3.

Moreover, the single-phase InSe thin films exhibit stability in atmospheric conditions, retaining superior electronic properties even after prolonged exposure. The method has been extended to flexible substrates like aluminum foil, showcasing its versatility and potential for future device manufacturing applications.

MBE is the deposition technique used also by Yue Li and coworkers in their study on the "Formation and Effect of Deposited Thin TiO_2 Layer With Compressive Strain and Oxygen Vacancies on GaAs (001) Substrate". The integration of metal oxides with GaAs semiconductors holds substantial promise for potential applications, yet it is impeded by challenges in producing heterostructures with superior interfacial quality, primarily due to the significant lattice mismatch and interdiffusion of As and Ga atoms.

To address these challenges and attain high-quality interfaces, this study endeavors to introduce a TiO_2 buffer layer between the functional oxides and GaAs. The researchers investigate the interface quality between TiO_2 and GaAs, elucidating the epitaxial growth mechanism of TiO_2 (110) films on GaAs (001) substrates. They highlight significant compressive strain, lattice distortion, and induced oxygen vacancies in the thin film.

The authors demonstrate that the TiO_2 passivation layer can effectively inhibit the diffusion of Ga and As atoms and suppress the formation of As-oxides and Ga-oxides at the interface of the TiO_2/GaAs heterostructure. This research lays the groundwork for integrating functional oxides on TiO_2-buffered GaAs, thereby enhancing the reliability and performance of GaAs-based electronic devices.

The following two papers, apply numerical simulations to extract information about the mechanical properties of thin films. The paper "The effect of contact aspect ratio and film to substrate elastic modulus ratio on stress vs strain up to the point of yield during flat punch thin film indentation of an elastic-plastic film" by A.D. Sinnot et al., analyses the mechanical behavior of thin elastic-plastic films under compression employing finite element simulations and experimental layer compression tests. This study stands out the importance of correcting for the substrate contributions to increase the accuracy of determining the confined modulus of the thin films. This way, some factors which can affect the accuracy of the nanoindentation testing results, like aspect ratio, Poisson's ratio choice, and substrate compliance, were explored. Experimental layer compression tests were carried out on a supported polystyrene film indicating good agreement with the theoretical simulations. The theoretical and experimental results provided key information about corrections to extract higher accuracy mechanical parameters from the layer compression test experiments.

Finally, the paper "On the viscoelastic drift behavior during nanoindentation" by Yu-Lin Shen, reports numerical studies based on three-element standard linear solid model to show how the viscoelastic materials during nanoindentation measurements can display prominent drift, even under low indentation loads, which are not related to the instrument-induced thermal drift. The results show that the direction and magnitude of the viscoelastic drift depend on the load-controlled indentation history and the relaxation state. Emphasis is done in that there is a potential complexity of the drift response related directly to the viscoelastic material itself. Therefore, the most important concluding remark of this paper is that caution is highly recommended when interpreting nanoindentation measurements without enough knowledge of the viscoelastic properties of the samples for accurate interpretation of the results.

As we reflect on the dynamic landscape of thin solid film research, it becomes evident that the insights gleaned and milestones achieved in 2022 will serve as catalysts pushing us towards a future where solid thin films continue to redefine technological innovation through their high transformative potential.

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