Merging Plasma Sputtering Deposition and Acoustic Wave Activation for the Deposition of Materials

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Abstract: In this research, we present the effects of the acoustoelectric activation of piezoelectric plates during the deposition of thin films in the presence of a plasma. As a results, surface acoustic waves in the substrate interact with the plasma enhancing the ion bombardment of the surface in specific regions, with produces a pattern of different composition, morphology of nucleation state.

1. Introduction

Plasma-based techniques are a mature technology for the deposition and processing of thin films. In this regard, several strategies such as thermal activation, substrate polarization, ion bombardment, or the application of electric and magnetic fields have been used to assist the growth of the depositing thin films. However, the activation of plasma thin films by their interaction with acoustic waves (AWs) on piezoelectric plates has remained mainly unexplored.

2. Methods

Electro-acoustically activated piezoelectric plates develop a pattern of AWs that in turn generates an oscillating polarization pattern that might interact with the charged species of a plasma. The possibilities of this methodology have been explored by magnetron sputtering (MS) deposition at oblique angles on AW activated LiNbO3 piezoelectric substrates. The sputtered materials for this study were dielectric thin films of TiO2 and SiOx, and Ag nanoparticles, and the LiNbO3 plates were activated with a pair of electrodes in a lateral field excitation configuration to generate standing thickness shear mode (TSM) AWs with a frequency around 3.4 MHz.

3. Results and Discussion

These experiments revealed that the AW-activation of the substrates produces localized effects in the features of the sputtered materials, reproducing a 2D pattern which replicates the AWs pattern. In the case of TiO_2 a SiOx dielectric films, this pattern showed differences in properties such as densification, optical properties, microstructure, crystallinity, and compositions (Figure 1).[1,2] In the deposition of Ag, this pattern showed differences in plasmon resonance absorption, particle size, and circularity, and amount of deposited material.[3]

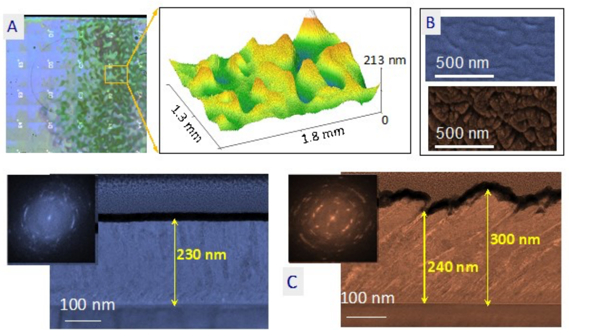

Fig. 1. TiO_2 sample grown under AW activation 2D pattern observed by the differences in topography (A), densification (B), and morphology and crystallinity (C).

4. Conclusion

Based on these results, which showcased that a new phenomenology enters into play when AWs interact with plasma, we proposed a model in which the development of a polarization electrical field on the substrate is the responsible for the focusing and acceleration of Ar+ plasma ions, whose impingement on the substrate produces the observed effects. This model relies on COMSOL and Monte Carlo simulations and makes use of the classical theory of Langmuir on the plasma sheath. From the point of view of plasma-based surface process technologies, this research set the basis for the fabrication of patterned thin films combining AW and plasma deposition procedures, which are largely utilized both at laboratory and industrial levels.

Acknowledgement

This research has been supported by the projects PID2023-147916NA-I00, PID2020-112620GB-I00 and PID2020-114270RA-I00 funded by MCIN/AEI/10.13039/50110001 1033. EU H2020 program grant agreement 899352 (FETOPEN-01-2018-2019-2020–SOUNDofICE). Project TED2021-130124A-I00 funded by AEI/10.13039/501100 011033/Unión Europea Next Generation EU/PRTR. M. Oliva-Ramírez acknowledges financial support from Grant IJC2020-045087-I funded by: MCIN/ AEI /10.13039/501100011033 and the European Union NextGeneration EU /PRTR. Guillermo Regodón acknowledges funding from the European Commission-NextGenerationEU through the “Plan de Recuperación, Transformación y Resiliencia” from the Spanish Government.

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