**Advanced Glancing Angle Sputtering Techniques: Transitioning from Thin Films to Nanocolumnar Structures**

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**Abstract**

Widely used in thin film production, sputtering is a technique that stands out for its scalability, cost-effectiveness, and eco-friendly nature, as it doesn't emit greenhouse gases. These attributes make it ideal for industry, where numerous examples of large-scale continuous thin films have been produced: solar cells, hard disk drives, integrated circuits, anti-reflective coatings and mirrors, among others. However, due to the unique techniques that emerge from nanostructured surfaces, it is of particular interest the use of sputtering for their fabrication. In fact, integrating this technique into conventional sputtering processes is relatively straightforward, as the critical parameter involves the substrate's inclination relative to the target material intended for film deposition [1,2], which we will call glancing angle deposition (GLAD).

This study will explore the implementation of glancing angle deposition within traditional sputtering techniques, focusing on the parameters influencing the morphology of nanostructured films, such as pressure, material, and substrate tilt angle. Additionally, we will examine the applications of these nanostructured films, ranging from antibacterial coatings for biomedical implants [3] to anti-multipactor coatings in the space industry [4], and address the challenges that lie ahead.

[1] Álvarez, R., García-Martín, J. M., Macías-Montero, M., González-García, L., González, J. C., Rico, V., ... & Palmero, A. (2013). Growth regimes of porous gold thin films deposited by magnetron sputtering at oblique incidence: from compact to columnar microstructures. *Nanotechnology*, 24(4), 045604.

[2] Sit, J. C., Vick, D., Robbie, K., & Brett, M. J. (1999). Thin film microstructure control using glancing angle deposition by sputtering. *Journal of Materials Research*, *14*(4), 1197-1199.

[3] Alvarez, R., Muñoz-Piña, S., González, M. U., Izquierdo-Barba, I., Fernández-Martínez, I., Rico, V., ... & García-Martín, J. M. (2019). Antibacterial nanostructured Ti coatings by magnetron sputtering: From laboratory scales to industrial reactors. *Nanomaterials*, *9*(9), 1217.

[4] Troncoso, G., García-Martín, J. M., González, M. U., Morales, C., Fernández-Castro, M., Soler-Morala, J., ... & Soriano, L. (2020). Silver nanopillar coatings grown by glancing angle magnetron sputtering for reducing multipactor effect in spacecrafts. *Applied Surface Science*, *526*, 146699.

**Short bio**

María Garrido is a PhD student at the Universidad Complutense de Madrid (UCM) in Madrid, Spain. She holds a degree in Physics from UCM, where she also completed a master’s degree in Biomedical Physics, demonstrating a strong interest in the applications of physics in biology and medicine. Her master's thesis was conducted at the Consejo Superior de Investigaciones Científicas (CSIC), where her interest in experimental physics was sparked. Following this experience, she began her PhD, specializing in the fabrication of nanocolumnar films via sputtering, with the aim of exploring their applications in biology and medicine. Specifically, she seeks to investigate the impact of these nanocolumns in cancer treatment through photothermal and magnetic hyperthermia techniques. Currently in the third year of her PhD, she is mastering fabrication and characterization techniques and striving for efficiency in these applications. She has also been to European Synchrotron Radiation Facilities (ESRF) in Grenoble, France, to pursue advanced characterization techniques for her nanocolumnar films. She is presently in Athens on a three-month research stay at the Demokritos Institute, where she is fabricating nanostructures from various materials, combining multiple materials in a single deposition. This approach allows for the creation of nanocolumns that leverage both the benefits of nanostructuring and the intrinsic properties of different materials. The technique of glancing angle deposition sputtering has been successfully implemented at Demokritos.

María has currently two publications and has participated in both national and international conferences. She has received numerous scholarships to support her research throughout her various stages as a student. Presently, her doctoral studies are funded by a scholarship from the Spanish Ministry aimed at training researchers and future university educators. Consequently, she has also taught numerous laboratory classes at UCM to several courses in the Physics and Chemical Engineering degree programs. María aspires to combine teaching and research in her future career, focusing on investigating new materials and their applications in biology and medicine.