

Engineering porous electroactive thin films by magnetron sputtering on nanorough substrates

B. Nano-engineered coatings and thin films: from design to applications

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Abstract

Magnetron sputtering (MS) is a versatile and scalable thin-film deposition technique that enables precise control over key material parameters such as crystalline phase, stoichiometry and phase composition. While conventional MS is widely used to fabricate dense, non-porous coatings on flat substrates, its potential for producing porous electrochemically active materials when deposited on nanorough substrates remains largely unexplored. In this work, we demonstrate that using nanorough carbon substrates dramatically alters the growth mechanism of sputtered metal nitride thin films, enabling the formation of highly porous microstructures with enhanced surface area [1].

Using nickel nitride and chromium nitride as model systems, we investigate thin-film growth on carbon nanotubes and carbon nanosheets. The intrinsic nanometric roughness of these substrates induces strong shadowing effects and non-competitive growth of incoming species, leading to open, quasi-fractal thin films that strongly contrast with the dense layers obtained on conventional flat substrates such as silicon or nickel. These experimental observations are supported by Monte Carlo simulations, which provide a detailed understanding of the underlying growth mechanisms. The robustness of this phenomenon across different nanorough substrate/thin-film systems suggests a universal and straightforward strategy to promote porosity in sputtered thin films using conventional MS processes. This bottom-up surface engineering approach offers a solid-state, solvent-free alternative to liquid-based synthesis routes and opens new opportunities for designing high-performance nanostructured materials. The resulting metal nitride/carbon nanomaterial hybrids exhibit significantly improved electrochemical performance for energy conversion and storage applications.

[1] B. Vigolo, E. Haye, J. Muller, Z.H. Ibupoto, S.-E. Benrazzouq, M. Pavía, A.C. García-Wong, A. Tahira, U. Aftab, P. Moskovkin, A.R. Mohamed, A. Besnard, D. Pilloud, S. Migot, J. Ghanbaja, M. Emo, N. Watiez, A. Achour, C. Douard, S. Vizireanu, G. Dinescu, S. Lucas, T. Brousse, J.-F. Pierson, Enabling Free Growth of Thin Films by Magnetron Sputtering for Blooming Microstructures, *Advanced Functional Materials* n/a (n.d.) e22071. <https://doi.org/10.1002/adfm.202522071>.