HfNbTaTiZr high-entropy thin films: from alloys to oxides for improved photocatalytic performance

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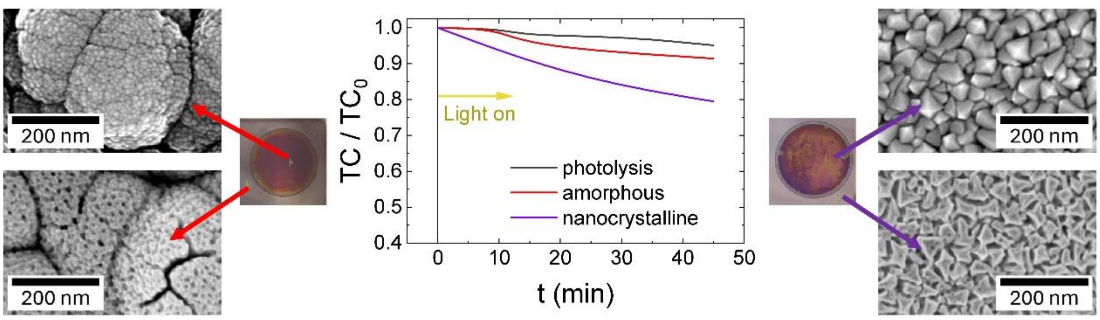
High-entropy materials (HEM), particularly high-entropy alloys (HEA) and high-entropy oxides (HEO), represent a novel class of multi-principal element materials that enable the exploration of diverse and variable properties within a single multicomponent system. While research has traditionally focused on bulk HEM, their thin film counterparts, prepared via pulsed laser deposition (PLD) or magnetron sputtering, offer unique advantages in tailoring microstructure and functional properties. Film deposited by PLD reveal enhanced control over the growth compared to other techniques, due to the nonthermal nature of the deposition process and the elevated kinetic and thermal energies of species involved. This work highlights the potential of HEA and HEO thin films for advanced applications, including photocatalysis, where tunable structural and optical characteristics play a crucial role.

Although the new catalytic properties of HEA have gained increasing attention, the performance of HEO remains largely unexplored, especially in the context of degradation of pharmaceuticals. HEA can be converted into HEO by anodization, producing high-surface-area nanostructured oxide films through a relatively simple, low-cost synthesis technique that is easily scalable for large-scale production. The use of new complex materials promises an improvement of photocatalytic activity, representing a science-to-technology breakthrough toward the development of HEO nanostructures capable of efficiently treating of wastewater containing pharmaceutical contaminants.

In this study, we prepared thin films based on the HfNbTaTiZr system, exhibiting a wide range of microstructures, characterized using various methods (XRD, AFM, SEM, XPS). Anodic oxidation induced extensive structural and optical transformations. Photocatalytic degradation experiments, using tetracycline as a model contaminant, demonstrated the potential of these films for wastewater treatment applications.



Acknowledgements: This work was supported by the NATO grant SPS MYP G6153.