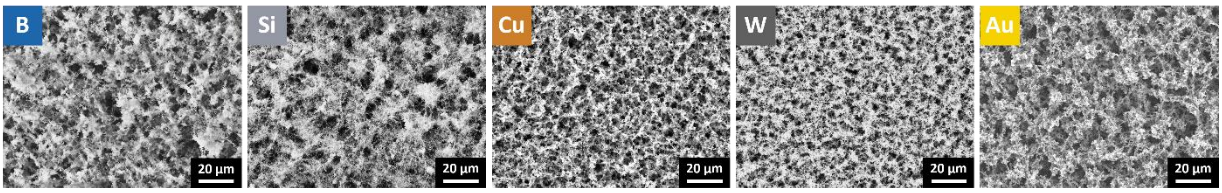
Femtosecond Pulsed Laser Deposition as a universal tool for nanofoam synthesis

Davide Orecchia[1,*], Alessandro Maffini[1], Alessandro Milani[1], Margherita Zavelani-Rossi[1], and Matteo Passoni[1]

[1] Energy Department, Politecnico di Milano, piazza Leonardo da Vinci 33, 20133 Milano, Italy
*Corresponding author email: davide.orecchia@polimi.it

Low-density nanostructured materials, and low-density nanofoams specifically, have gained significant attention in the material science community due to their unique properties, such as extremely high surface area-to-volume ratio—enabling applications in catalysis [1], energy storage [2], gas sensing [3], pollutant removal [4]—and efficient laser energy absorption, of great interest in advanced schemes for laser-matter interaction applications [5].
A variant of the well-known Pulsed Laser Deposition technique, employing femtosecond laser pulses (fs-PLD) is especially promising to obtain such materials: the direct nanoparticle emission and universality of the ultrafast ablation mechanism [6] allow a fine control of the film properties down to the nanoscale, with great flexibility in the choice of material used. Moreover, multiple elements codepositions are made possible thanks to the technique universality.
We present our results in the production and characterization of cluster-assembled nanofoams [7] from a variety of elements with different chemical and physical characteristics—boron, carbon, silicon, copper, tungsten, gold—with tunable density (from bulk to 10s of mg/cm^3) and thickness (from few to 100s of μm). The aggregation and growth mechanism of the nanofoams are discussed, showing how the interplay between process parameters and material properties affects the nanofoams macro- and nano-scale features.
To showcase the technique potential, we discuss the production of nanofoam-based targets for high-intensity laser-matter interaction experiments, and illustrate the main advantages of the fs-PLD technique in relation to the applications requirements, such as the ability to control material composition and morphology at different spatial scales.



References:
[1] Sun S. et al. Journal of Colloid and Interface Science 626 (2022)
[2] Zhu H. et al., ACS Applied Energy Materials 5.6 (2022)
[3] Kim S. et al., Sensors and Actuators B: Chemical 358 (2022)
[4] Ma J. et al., Applied Catalysis B: Environmental 317 (2022)
[5] Passoni M. et al., Plasma Physics and Controlled Fusion 62.1 (2019)
[6] Rethfeld B. et al., Journal of Physics D: Applied Physics 50.19 (2017)
[7] Maffini A. et al., Applied Surface Science 599 (2022)