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INVITED oral presentation

Recent advances of nanoscale mechanical testing methods in nano-architected 3D printed materials

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The combination between **high strength and low density** has been an ultimate goal for materials engineering since centuries and has recently gained even more importance with the latest developments of aerospace engineering, nanotechnology and biomedical sciences. In addition, the **potential impact** for the development of novel lightweight materials becomes even more critical if we focus the attention on the urgent need for reduction of CO_2 emissions and improvement **of energy and resource efficiencies.**
Recently, **Nano-Architected Mechanical Metamaterials (NAMM**, fig. 1(a)) have been proposed, also referred to as **nanolattices**, where architectural and materials size effects lead to unprecedented levels of stiffness (***E/ρ***) and strength to density ratios (***σ_f/ρ***) [1].
Unfortunately, the improvement of strength is usually not accompanied by a similar improvement of **toughness and ductility**, because of the effects of imperfections and flaws on structural reliability.
In this presentation, an overview will be given on recent advanced on the production of NAMM, with specific focus on the advanced **nanoscale mechanical characterization methods** that can help understanding the process – microstructure – property correlations in such materials.
We will discuss on the environmental effects on fracture toughness (fig. 1(b)) and surface energy of 3D printed glassy-carbon nano-ceramics and polymers, as obtained by Two-Photon Lithography (TPL) Direct Laser Writing (DLW) method.
The results demonstrate that crack propagation resistance of NAMM is predominantly a surface-dominated process that can be controlled by careful analysis of surface sub-micrometre flaws and residual stress coming from the printing and post-printing processes [2].

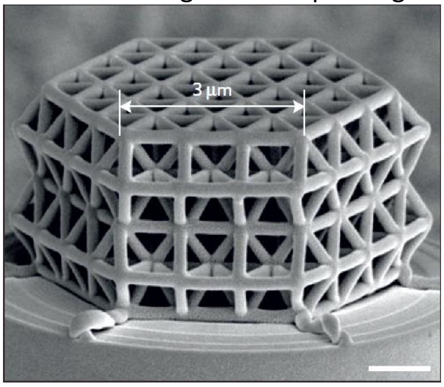

Fig. 1(a) Octet-truss based micro-architecture, obtained by TPL and pyrolys [1].

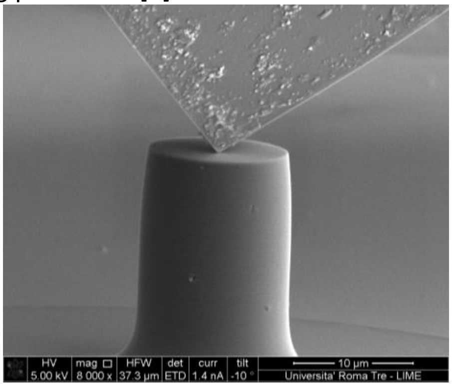

Fig. 1(b) Micro-scale fracture toughness (pillar splitting) of 3D printed micro-pillars [2]

[1] J. Bauer, L. R. Meza, T. A. Schaedler, R. Schwaiger, X. Zheng, and L. Valdevit, "Nanolattices: An Emerging Class of Mechanical Metamaterials," Adv. Mater., vol. 29, no. 40, pp. 1–26, 2017, doi: 10.1002/adma.201701850.

[2] E. Rossi, J. Bauer, and M. Sebastiani, "Humidity-dependent flaw sensitivity in the crack propagation resistance of 3D-printed nano-ceramics," Scr. Mater., vol. 194, p. 113684, 2021, doi: 10.1016/j.scriptamat.2020.113684.

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