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Ye-eun Na

Dahye Shin

Kisun Kim

Dongchan Jeon
KAIST, dongchan.jang@kaist.ac.kr

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Ye-eun Na[1], Dahye Shin[1], Kisun Kim[2], Seokwoo Jeon[2] and Dongchan Jang[1]
[(1)] Department of Nuclear and Quantum Engineering, KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon 34141, South Korea; dongchan.jang@kaist.ac.kr
[(2)] Department of Materials Science and Engineering, KAIST, 291 Daehak-ro, Yuseong-gu, Daejeon 34141, South Korea

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Density-strength tradeoff appears to be an inherent limitation for most materials [1] and therefore design of cell topology that mitigates strength decrease with density reduction has been a long-lasting engineering pursue for porous materials. Continuum-mechanics-based analyses on mechanical responses of the conventional porous materials with bending-dominated structures often give the density-strength scaling law following the power-law relationship with exponent of 1.5 or higher [2], which consequentially determines the upper bound of the specific strength for a material to reach. In this work, we present a new design criterion capable of significantly abating strength degradation in lightweight materials, by successfully combining size-induced strengthening effect in nanomaterials with architectural design of cellular porous materials. Hollow-tube-based 3D ceramic nano-architectures satisfying such criterion were fabricated in large area using Proximity field nano-Patterning (PnP) [3] and atomic layer deposition (ALD). Experimental data from micro-pillar compression confirmed that the strengths of these nano-architectural materials scale with relative densities with power-law exponent of 0.93, hardly observable value in the conventional bending-dominated porous materials. Our discovery of new density-strength scaling law in the nano-architectured materials will contribute to creating new lightweight structural materials attaining unprecedented specific strengths overcoming the conventional limit.

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