Accepted Manuscript

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 PII:
 S0022-5096(17)30961-4

 DOI:
 https://doi.org/10.1016/j.jmps.2018.08.022

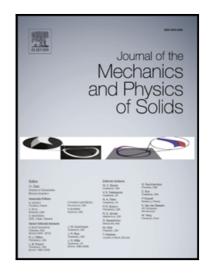
 Reference:
 MPS 3427

To appear in: Journal of the Mechanics and Physics of Solids

Received date:23 October 2017Revised date:15 August 2018Accepted date:21 August 2018

Please cite this article as: Colin Bonatti, Dirk Mohr, Mechanical Performance of Additivelymanufactured Anisotropic and Isotropic Smooth Shell-Lattice Materials: Simulations & Experiments, *Journal of the Mechanics and Physics of Solids* (2018), doi: https://doi.org/10.1016/j.jmps.2018.08.022

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Mechanical Performance of Additively-manufactured Anisotropic and Isotropic Smooth Shell-Lattice Materials: Simulations & Experiments

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Abstract. A novel family of smooth-shell structures is introduced as mechanical metamaterials of exceptional specific energy absorption capacity. The proposed shell structures respect all symmetries of the face-centered cubic crystal. To obtain a smooth curvature shell structure, the exact shape of the shell mid-plane is determined through the minimization of a bending-energy based measure of the overall curvature. Among the members of this new family, the mechanical properties of a Triply Periodic Minimal Surface (TPMS) -like architecture and an elastically-isotropic derivate are investigated in detail. The TPMS-like structures showed important anisotropy in both its small and large strain responses, with loading-direction dependent differences in stiffness of more than 100%. The mechanical properties of the elastically-isotropic shell-lattice turned out to be close to the mean value for all directions of loading for the TPMS-like structures. For relative densities ranging from 1% to 50%, the shell-lattices always exhibited a higher mechanical performance than truss-lattices of equal density. For relative densities greater than 20%, the mechanical response of the shell-lattices is more stable than that of truss-lattices which makes them particularly suitable as higher order structures in hierarchical metamaterial design. The computational results are partially confirmed through compression experiments on additively-manufactured stainless steel specimens. A direct comparison of the stress-strain curve of additively-manufactured stainless steel 316L with that of sheets made from the same alloy revealed an increase in yield strength of about 30% related to the selective laser melting process.

Keywords: Mechanical metamaterials, architected materials, unit cell analysis, shelllattices, stiffness, energy absorption Download English Version:

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