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THE LOCALIZED DAMAGE EVOLUTION OF AlSi10Mg BCC LATTICE STRUCTURES

Ninian Sing Kok Ho[1], Peifeng Li[2] and Gin Boay Chai[1]

[1] School of Mechanical and Aerospace Engineering,
Nanyang Technological University, 50 Nanyang Avenue Singapore 639798,
ho0009an@e.ntu.edu.sg, mgbchai@pmail.ntu.edu.sg
[2] School of Engineering, James Watt South Building, University of Glasgow, Glasgow G12 8QQ,
Peifeng.Li@glasgow.ac.uk

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While mechanical properties of SLM metal lattices have been widely studied[1], little attention has been paid to the localized damage evolution typical of such lattice structures. Consequently, their mechanical properties have only been investigated on the macro scale, much like those of stochastic metal foams, even though they are geometrically periodic. In addition, finite element models are unable to accurately reproduce localized shear bands commonly observed in these lattices under compression[2]. This technical contribution hopes to address these deficiencies. Using AlSi10Mg as the parent material, lattice structures based on the simplest and most common unit cell topology, namely the body-centered cubic (BCC) topology, were manufactured by SLM. After determining the bulk properties of the SLM AlSi10Mg, the lattices were tested in quasi-static uniaxial compression. Smaller lattices were also manufactured by the same process for in-situ SEM observation of lattice deformation and failure modes while they were loaded in compression. The predictions using finite element simulations of the compression tests were in excellent agreement with the experimental results. The results showed that within a lattice block, stresses were concentrated at its nodes. Furthermore, different nodes experienced different stress levels, depending on their relative positions within the lattice. The deformation of the lattice block was also found to be non-uniform, such that a laterally symmetrical, roughly "X" shaped crush band pattern was formed gradually with the topmost and bottom-most layers of unit cells deforming last. Barrelling was also observed. In-situ SEM micrographs of the smaller lattices reveal that cracks mostly form near the lattice nodes as predicted by the FE simulations. The novelty of this work lies in the identification of the nodes experiencing the highest localized stresses due to the complex boundary conditions imposed on the individual unit cells and the relationship between the localized damage in a lattice under compression and its stress-strain response.

REFERENCES

[1] P. Li, "Constitutive and failure behaviour in selective laser melted stainless steel for microlattice structures," *Materials Science and Engineering: A*, vol. 622, pp. 114-120, 2015.

[2] G. N. Labeas and M. M. Sunaric, "Investigation on the Static Response and Failure Process of Metallic Open Lattice Cellular Structures," *Strain*, vol. 46, pp. 195-204, 2010.