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Visualization of engineered residual strain in additive manufacturing materials by Bragg Edge neutron imaging

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Additive Manufacturing is a quickly developing set of technologies that is revolutionising the manufacturing industry worldwide (by, for example, greatly reducing the number, weight and cost of parts of a finished product and by allowing the manufacture of complex shapes), despite a number of still open problems, such as the introduction of residual tensile stress (in particular on the surface regions of Selective Laser Melting (SLM) produced parts) limiting the fatigue and chemical resistance and causing deformation and cracks.
A post-process technique that has been shown to limit and even counteract this effect is Laser Shock Peening (LSP), which can introduce compressive stress in the surface region of metals through the application of repeated concussive shockwaves using a laser.
Bragg-edge neutron imaging is particularly well suited for investigating the effect of such treatment because it can probe several centimeters of relevant engineering material (such as steel and Nickel) and map with ˜100 um spatial resolution the strain state of a finished product. Such technique is here applied to LSP-treated 316L additively manufactured steel samples and the resulting strain field is retrieved and visualized using a specifically design data treatment algorithm.
We therefore demonstrate that the effects of LSP can be successfully mapped with Bragg Edge imaging and we find that its effect reaches down to 200 micrometer, with even the introduction at the surface of a beneficial compressive stress.
After such proof-of-concept measurement demonstrated the usefulness of neutron imaging for additive manufacturing, the natural follow up is to utilize the acquired know-how to optimize the parameters of LSP to achieve the desired strain state depending on the application.

Position

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