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Microstructure and residual stress interactions in metal additive manufacturing: post-build assessment and new in-situ methods

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Layer-wise addition of metal to directly form components or add coatings via laser powder bed fusion (LPBF) or laser directed energy deposition (DED) can generate very high levels of residual stress which affect component durability if not adequately addressed. These techniques also result in novel, non-equilibrium microstructures, sometimes with desirable features, that interact with traditional residual stress relief and microstructure manipulation heat treatments.

In LPBF nickel superalloy 718, neutron diffraction was used to demonstrate that a complex residual stress state can persist through a non-recrystallising heat treatment at 960 °C plus subsequent ageing. The same treatment has been previously shown to relieve residual stresses and promote grain growth in conventionally manufactured material. This discrepancy is attributed to the presence of nano-scale intercellular precipitates and a large concentration of existing dislocations, both consequences of the LPBF process, which act to impede recrystallisation and creep processes. The residual stress state is shown to influence the long-crack fatigue threshold at low stress ratios. Higher temperature annealing successfully relieved residual stresses but resulted in recrystallisation and grain growth which reduced the yield stress.

To further explore residual stress and phase evolution during additive manufacturing, an in-beamline laser DED capability is being developed at ANSTO for both neutron and synchrotron use.

Level of Expertise

Early Career <5 Years

Presenter Gender

Man

Pronouns

He/Him

Which facility did you use for your research

Australian Centre for Neutron Scattering

Students Only - Are you interested in AINSE student funding

Do you wish to take part in the Student Poster Slam

Condition of submission

Yes

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