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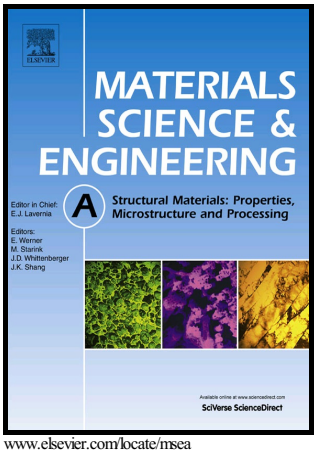

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Abstract

The formation mechanism and properties of white layers created during broaching are not well investigated and understood to date. In the present study, multiple advanced characterization techniques with a nano-scale resolution, including transmission electron microscope (TEM), transmission Kikuchi diffraction (TKD), atom probe tomography (APT) as well as nano-indentation, have been used to systematically examine the microstructural evolution and corresponding mechanical properties of a surface white layer formed when broaching the nickel-based superalloy Inconel 718.

The TEM observations showed that the broached white layer consists of nano-sized grains, mostly in the range of 20 nm to 50 nm. The crystallographic texture detected by TKD further revealed that the refined microstructure is primarily attributed to strong shear deformation. Co-located Al-rich and Nb-rich fine clusters have been identified by APT, which are most likely to be γ' and γ'' clusters in a form of co-precipitates, where the clusters showed elongated and aligned appearance associated with the severe shearing history. The microstructural characteristics and crystallography of the broached white layer suggest that it was essentially formed by adiabatic shear localization in which the dominant metallurgical process is rotational dynamic recrystallization based on mechanically-driven subgrain