NANOMECHANICAL TESTING FOR CRYSTAL PLASTICITY CONSTITUTIVE FRAMEWORK IDENTIFICATION AT HIGH STRAIN RATES

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Shot-Peening (SP) is a surface mechanical treatment that consists in propelling hard particles, called shot, onto a ductile metallic surface at high velocity to induce subsurface residual compressive stresses. It is widely used in the industry to increase fatigue life and wear resistance of treated parts. Shot-peening induced macroscopic residual stresses (*e.g.* Type I) predictions using finite element analysis or analytical method is today already well assessed. However, recent works [1] revealed that spherical indentation in specific crystal orientations could induce subsurface intragranular tensile stresses. In the shot-peening context, such intra-granular (*e.g.* Type III) residual stresses could influence structure's High Cycle Fatigue (HCF) behavior and macroscopic residual stresses stability over the load cycles It would also favor early stage plasticity and crack initiation.

Shot-peening simulations at the crystal scale would therefore provide essential quantitative inputs for treated parts fatigue life prediction. Such simulations require to select relevant constitutive frameworks representing the crystal behavior at high strain rate (up to 10^6 s^{-1}) and accounting for repeated impact induced cyclic effects. Also, identification of such behavior will require mechanical tests at the crystal scale under process-representative test conditions.

In the present work, a new methodology for crystal plasticity inverse identification for large strain rate ranges is developed. It relies on high-strain rate micropillar compression tests performed with a recently developed nano-indenter test apparatus [2], at strain rates up to 10^2 s^{-1}. Micropercussion induced residual imprints are also experimentally generated to provide material behavior inputs at higher strain rates. Both tests are combined for inverse identification of two different crystal plasticity constitutive frameworks for copper. Unicity and stability of the given coefficients are studied using cost function plots and an identifiability indicator developed by Renner et al. [3].

Further works will focus on high strain rates Berkovich indentation tests to complete the developed methodology. Experimental data will also be generated at higher strain rates and for repeated impacts, using a currently developed impact shot gun that will propel shots at shot-peening velocity with a spatial accuracy of $50\ \mu m$.

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