ICSMA19 Metz, France, June 26 - July 1, 2022
International Conference on Strength of Materials

Slip Localization and the Prediction of Fatigue Strength of Polycrystalline Alloys

Jean-Charles Stinville[a], Tresa Pollock[b]

[a]*Materials Science and Engineering, University of Illinois at Urbana-Champaign.*

[b]*Materials Department, University of California Santa Barbara.*

[a]*Jcstinv@illinois.edu*

With increasing applied stress, metallic materials experience irreversible deformation, manifested in localized slip events that result in unexpected fatigue failure upon repeated cycling. Recent advances in accelerated fatigue testing, in-situ electron microscopy, digital image correlation methods and multi-modal data analysis have been integrated to quantitatively characterize the evolution of these slip events from the earliest stages of cycling at the nanometer scale over large fields of view in relation to material crystal structure and microstructure. Statistical analyses of slip events for a large collection of materials with face-centered cubic, hexagonal close-packed and body-centered cubic structures have been performed. Relations between the yield and ultimate tensile strength, cyclic fatigue strength and the amplitude and spacing of slip localization events are uncovered (Fig.1). It is observed for the first time that the fatigue strength of fcc, hcp and bcc metallic alloys can be predicted by the amplitude of slip localization during the first cycle of loading.

Keywords: Plastic localization, Fatigue strength, Deformation Slip, Polycrystalline Metallic Materials.

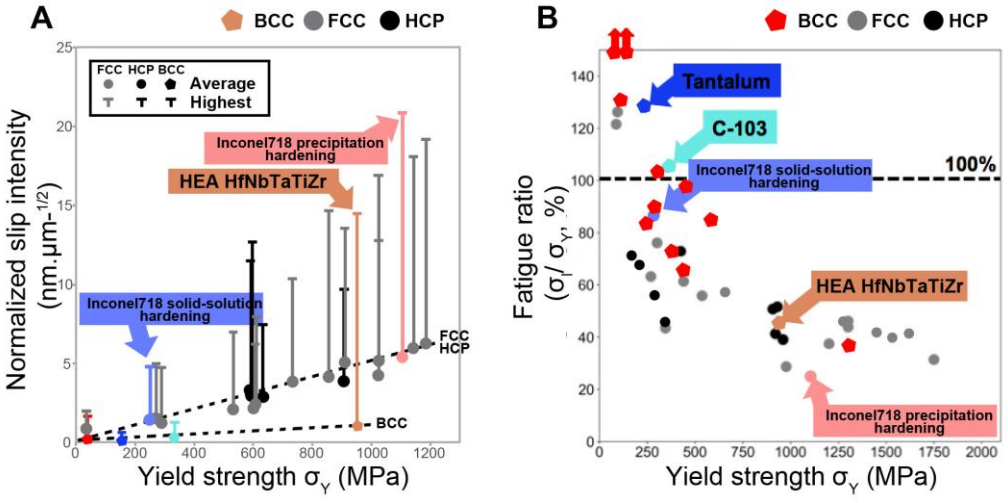

Fig.1 : **Relation between fatigue strength and slip localization amplitude for metallic materials.** Materials are plotted as a function of their yield strength (x-axis). **A** Slip localization amplitude (average and highest) as a function of the yield strength of metallic materials. Slip localization amplitude is obtained via the analysis of hundreds of thousands of slip events during monotonic loading at the macroscopic yield. **B** Fatigue ratio (fatigue strength over yield strength) as a function of the yield strength.