LIMITATION OF HALL-PETCH RELATIONSHIP FOR INTERPRETING SCRATCH ON POLYCRYSTALLINE COPPER USING SPHERICAL INDENTER

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It is widely known that grain boundary can play a big role in influencing crystal deformation (Hall-Petch effect). This has been intensively studied and widely used as a strengthening mechanism for material component design and manufacture. In the recent years, grain size gradient was introduced by modifying the surface of material component to demonstrate that high strength could be achieved with little compromise in losing ductility [K. Lu, Science 345 p.1455 (2016)]. However, in addition to the grain refinement introduced by the surface treatment, there are also work-hardening, even residual stress; as a result, it is difficult (sometimes impossible) to separate which mechanism is key to provide the strengthening effect. In this study, a well-defined interface between coarse grain and fine grain copper was created using electro-deposition method to provide a simplified case for investigation of the grain size refinement influence: the contribution from work-hardening and residual stress is considered as negligible. Micro-scratch was carried out using a spherical indenter (R=20µm) across this clear boundary as demonstrated in the Figure 1. Preliminary results suggested that the grain orientation could be a key factor in determining the measured scratch hardness, sometime even more significant than the contribution from grain size strengthening for scratch resistance. This work contributes new knowledge to better tune the crystal orientation/grain size combination to achieve the desired mechanical strength/ductility at small scales. .

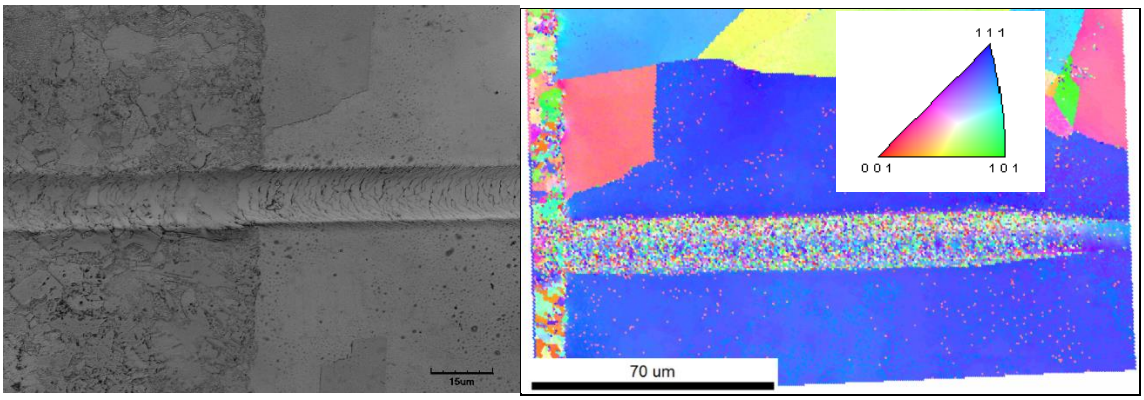

Figure 1 – Optical and EBSD images to show the clear boundary between coarse grain and fine grain with a scratch going through it.