

OBSERVING THE SIZE EFFECT IN COPPER-CHROMIUM-ZIRCONIUM USING SPHERICAL NANOINDENTATION

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Small scale testing techniques are increasingly being used to measure the mechanical properties of irradiated materials, where there are often only limited sample volumes available or facility handling regulations restrict the activity level of specimens. Results from these tests are convoluted by the size effect, a phenomenon that causes an apparent increase in strength of the material when the size of the test piece is decreased. An example of the indentation size effect can be seen in Figure 1. The internal (microstructural) length-scale of the material system is also known to influence the measured mechanical properties. If engineering-relevant, macro-scale properties are to be accurately predicted for metallic and other crystalline solids that deform by dislocation slip, then the influence of both aspects of the size effect must be better understood. Presented here is initial work investigating the observed size effect in copper-chromium-zirconium (CuCrZr), which is the primary candidate for structural, high heat flux components in future fusion reactors. This alloy is precipitation-hardened and the dominant length scale responsible for strengthening of the material is average spacing between Cr precipitates (Figure 2). When subjected to heat treatments the precipitate spacing increases, thus providing a variation in internal length-scale for this research. To observe the effect of changing external length-scale, various techniques have been performed: nanoindentation using spherical tips of radii between 1 μm and 150 μm , small-scale tensile testing, and Vickers indentation. Results from these techniques will be compared and the ability of new finite element models to predict macro-scale tensile results will be assessed.

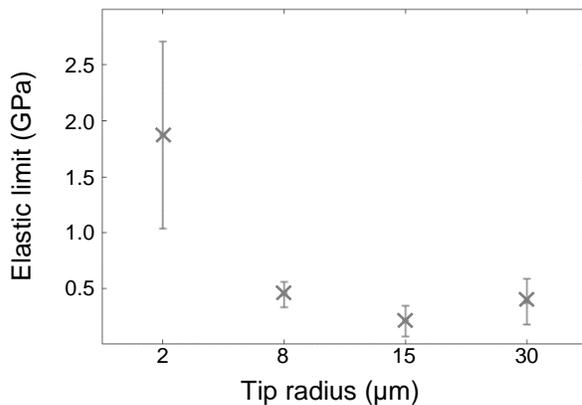


Figure 1 – Indentation size effect seen in as-received CuCrZr

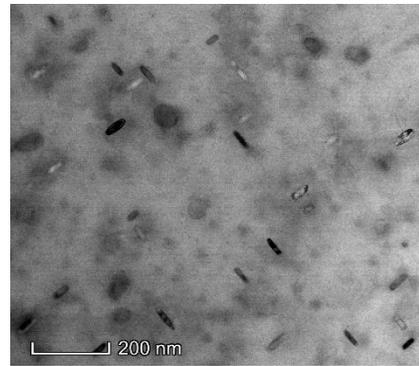


Figure 2 - Bright-field TEM image of chromium precipitates in CuCrZr heat-treated at 700C [1]

[1] Images courtesy of Dr. Joven Lim, with thanks to Prof Grace Burke for the use of facilities at The University of Manchester

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