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Strain Gradients in Thermally Cycled Cu Films
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Introduction: Thin films bonded to rigid substrates can sustain significantly larger flow stresses than their bulk counterparts. The theory of strain gradient plasticity [1, 2] accounts for this strengthening by relating the increase in flow stress to the presence of plastic strain gradients. For thermally cycled thin films on rigid substrates, the plastic strain distribution through the thickness of the film can be determined by measuring the elastic strain distribution since the total (thermal) strain is uniform through the thickness. Our goal is to determine the plastic strain distribution in thermally cycled Cu films on Si substrates from the measurement of the elastic strain distribution.

Methods and Materials: Three Cu film thickness were studied: 0.87 μm, 1.25 μm, and 1.73 μm. The elastic strain distribution was studied by grazing incidence diffraction (GID) [3] in both the as-deposited and thermally cycled films. Three diffraction peaks, the (220), (200), and (111), were used in order to estimate the effects of strain anisotropy.

Results: Our results are presented in Figure 1. As is often the case with inverse problems, extracting the true elastic strain profile from the data in Figure 1 is difficult. However, the thermally cycled films consistently show significant strain relaxation near the surface. Strains near the substrate interface cannot be studied with GID due to the insensitivity of the technique to buried interfaces. An attempt was made to study this interface by GID through the Si substrate at 26.9 KeV, but this resulted in insufficient intensity to make a measurement.

Conclusions: Our experiment confirms the presence of plastic strain gradients near the surface of the Cu film. Strain gradients near the substrate interface cannot be measured using this technique. Reasons for the presence of strain gradients in the as-deposited films are currently under investigation.

References:

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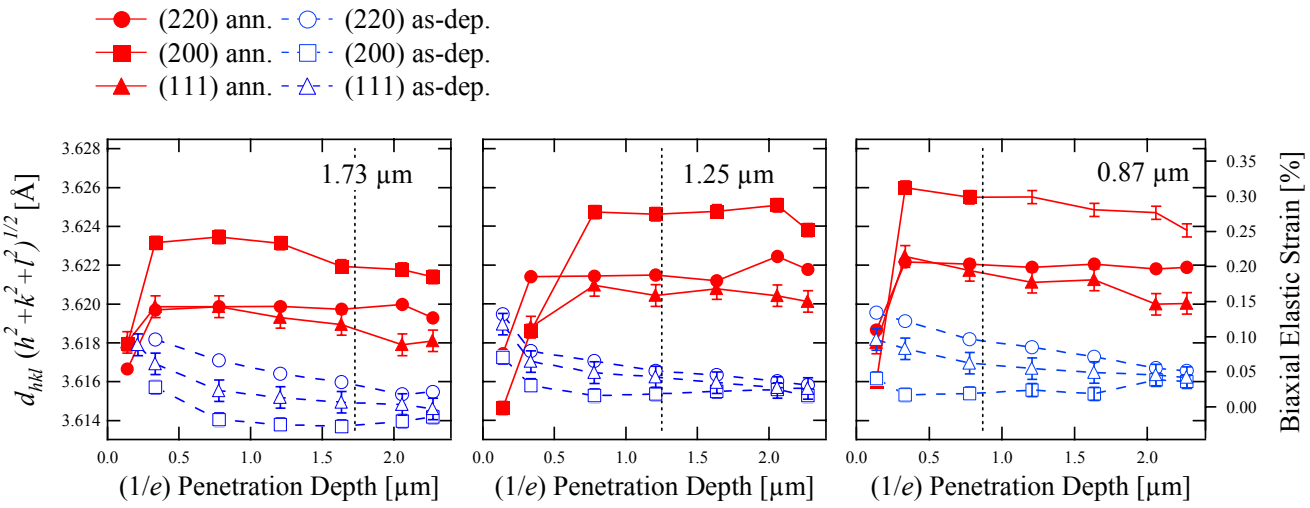

Figure 1. Elastic strain gradients in Cu films. The solid and dotted lines refer to the thermally cycled films and as-deposited films, respectively. The *(hkl)* reflection used for the measurement is denoted by different markers, as shown in the legend. The plastic strain is given by 0.9% minus the biaxial elastic strain. All data were taken with an energy of 8960 eV.