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# Annealing effect on coherent-incoherent interface tri-component nanoscale metallic multilayer thin films

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[1] RL Schoeppner et al., Mater. Res. Lett. (2015).

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## Annealing effect on coherent-incoherent interface tri-component nanoscale metallic multilayer thin films

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Multilayer coatings provide an excellent medium for the study of nanoscale materials' properties. It has previously been shown that Cu/Ni/Nb tri-component multilayers with coherent and incoherent interfaces have a greater capacity for strain hardening than a Cu-Ni/Nb system, in which only incoherent interfaces are present [1]. This experimental evidence supports the predictions of the confined layer slip model in that the modulus-mismatched coherent interfaces in the tri-layer system increase the capacity of the multilayer to store dislocations, leading to greater hardenability.

In this work the same Cu/Ni/Nb tri-layers and Cu-Ni/Nb bilayers are investigated with regard to their thermal stability. In principle, the existence of coherent interfaces is expected to stabilise the tri-layer system against grain growth and hence softening of the multilayer following annealing. In actual fact, both the tri-layer and bilayer systems were observed to **increase** in hardness following annealing procedures at 300C and 500C (figure 1). X-ray diffraction (XRD) experiments suggest that microstructural changes are taking place in the coatings following even a modest anneal; peaks from Cu and Ni in the tri-layer system are observed to begin to merge and there is some evidence for new peaks forming.

TEM specimens of the tri-layer and bilayer systems were produced in order to better investigate the microstructure of these multilayer systems before and after annealing. An FIB lift-out from an indented region of the as-deposited tri-layer indicates that the Cu/Ni interface is not completely coherent and that the three layers deform quite equally under indentation loading. Analysis of the annealed tri-layer and bilayer systems revealed that while the grain size is relatively stable, a Ni-Nb intermetallic is observed to form at the Ni/Nb, Cu-Ni/Nb and Cu/Nb interfaces (figure 2). It was also observed that considerable interdiffusion of Cu and Ni took place at 500C.

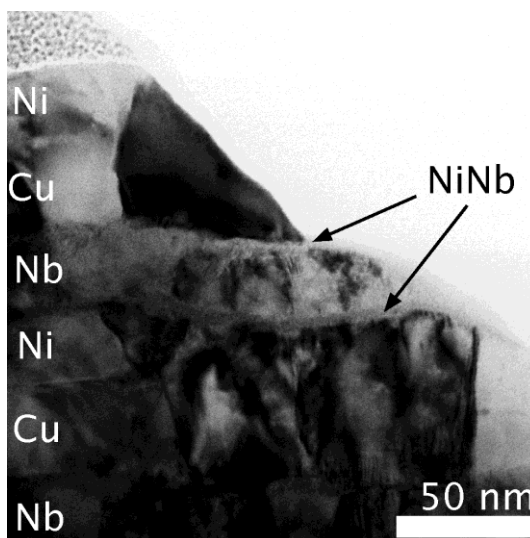
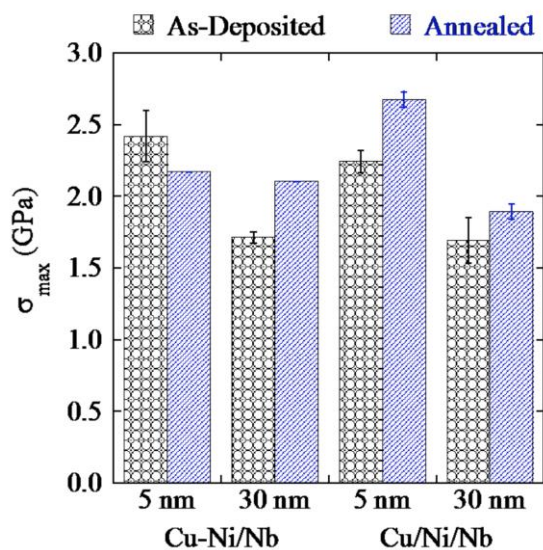


Figure 1 – a comparison of hardness in Cu-Ni/Nb bilayer and Cu/Ni/Nb trilayers before and after a 300C anneal.

Figure 2 – BFSTEM image of a 30 nm Cu/Ni/Nb trilayer following a 500C anneal, note the Ni-Nb intermetallic layers.

[1] RL Schoeppner et al., Mater. Res. Lett. (2015).