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The Role of Bcc Mg/Nb Interfaces in Nanocomposite Deformation Observed via *In-Situ* Mechanical Testing in TEM

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Magnesium (Mg) alloys attract intense attention for being one of most promising lightweight structural materials for automobile and aerospace applications [1,2]. However, their low strength and poor ductility, caused by scarcity of easy slip systems and localized shear due to twinning in hexagonal close-packed (hcp) structures limit their applicability. [3,4]. Improving the strength without sacrificing ductility remains a significant challenge. Many techniques, such as non-traditional processing [5,6], grain refinement [7], and alloying with rare earth elements [8], have been applied to tune the relative activity of slip and twinning in Mg alloys, improving deformability while maintaining strength. Mg and Mg alloys can also be strengthened through tailoring the microstructure of Mg-based composites, such as in Mg metal laminates [9-11].

Mg/Nb nanolaminates have been proposed to be effective in improving ductility and strength in Mg. Since bcc Mg can be stabilized by being sandwiched in between bcc/bcc Mg/Nb interfaces when the individual layer thickness is below 5 nm [9, 10], the ductility is improved as bcc Mg has additional active room temperature slip systems as compared to hcp Mg. However, the experimental evidence supporting this is still sparse. In situ mechanical testing is a useful tool for real-time observation of deformation mechanisms at nanometer scales inside a transmission electron microscope (TEM). Our results directly validate the hypothesis that bcc Mg could accommodate severe plastic deformation. Moreover, in situ high-resolution TEM (HRTEM) reveals that in bcc/bcc Mg/Nb, a reversible bcc-hcp phase transformation in Mg could occur during loading and unloading, as shown in figure 1.

In summary, the fundamental understanding of deformation mechanisms of bcc Mg in Mg/Nb laminates is investigated. The bcc Mg exhibits enhanced ductility due to (1) additional active slip systems in comparison to hcp Mg and (2) a bcc-hcp phase transformation in Mg layers. The enhanced ductility exhibited by nanoarchitectured Mg in this investigation may have future implications in the design of Mg alloys [12].

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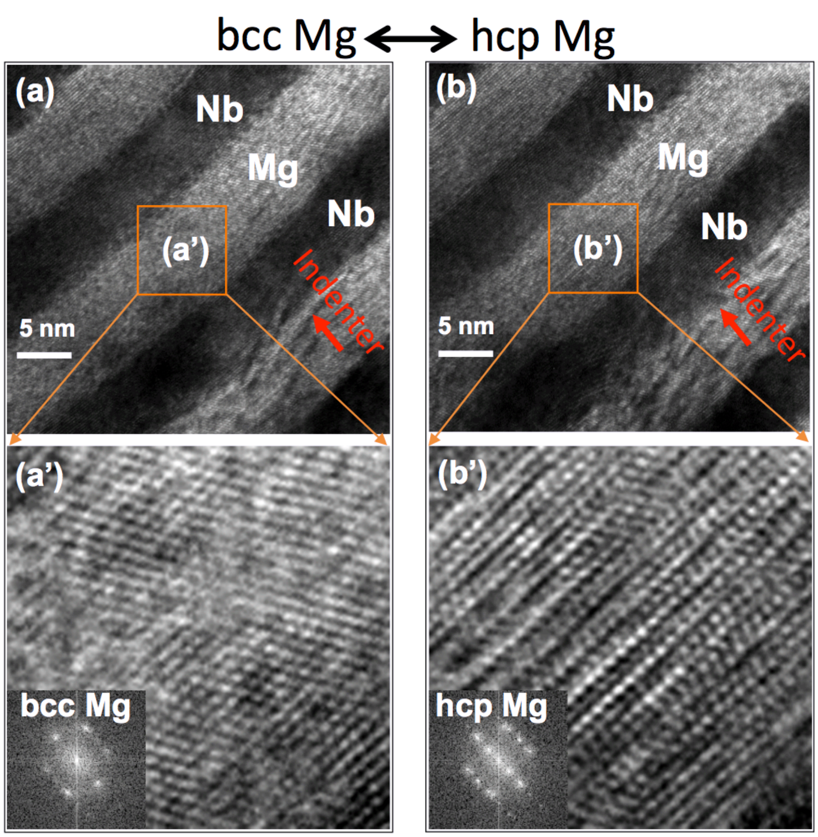

Figure 1. The phase transformation of Mg from bcc Mg to hcp Mg during in situ nanoindentation inside a transmission electron microscope. (a) HRTEM snapshot and (a') magnified image demonstrate bcc structure of Mg by the inset FFT (a'); (b) HRTEM snapshot and (b') magnified image demonstrate hcp structure of Mg by the inset FFT. (a) and (b) are from same location.

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