Nanoindentation response of NiTi shape memory thin films

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Shape memory alloys (such as NiTi) have fascinated scientists for their ability to "remember" their original shape when heated. Their thin-film embodiment has drawn much attention because of their potential use as actuation materials in microelectromechanical systems (MEMS). NiTi thin films are commonly sputtered in an amorphous form and require a high-temperature crystallization step to create their crystalline (actuating) form. Their amorphous form has also drawn much scientific attention, since it allows one to tailor microstructures with crystallization and the associate properties that are controlled by microstructure. The crystallization process is driven by nucleation and growth and can be quantified using the Johnson-Mehl-Avrami-Kolmogorov (JMAK) theory. This talk will present our findings of the effects of the extent of crystallization on the mechanical properties of these films. The films exhibited a bimodal elastic modulus response—softer when indented in crystalline regions; harder in amorphous ones. Interestingly, when indents are in the amorphous region of a semi-crystalline film, the observed modulus is harder than the as-deposited film, which is attributed to the nanostructure of the film. Conversely, the modulus is much softer when it is indented in the crystalline region. This variation indicates that the local material structure can be utilized to modify mechanical properties at the small scale.