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Hardness of the $Fe_{81}Ga_{19}$/Si(100) film measured by the nano-identation method

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Abstract

$Fe_{81}Ga_{19}$ alloy is an auxetic material, which means that its Poisson's ratio along the [110] direction, $V_{[110]}$, is negative. When this alloy is deposited on a single-crystal Si(100) wafer, the film is highly (110) textured. Thus, if we indent the film plane with a Berkovich indenter vertically, the apparent hardness obtained with the parameter $V_{eff} = V_{[110]} = -0.55 < 0$ should be larger than that with $V_{eff} = V_{[110]} = +0.30$. This is reasonable, because if V_{eff} is negative, the deformed material under the pressing indenter tends to push the tip slightly upward (or backward). As a result, the measured depth of circle of contact, hp, of this auxetic film is smaller than *it should be* under a fixed force, F, and, moreover, since the hardness H ≡ F/[24.5(hp)2], the apparent (measured) hardness must be larger. We have made a series of (Fe100-xCox)81Ga19/Si(100) films, and measured their hardness. The results indicate that: [1] when $0 \leqq x < 7$ at.%Co, the films (or alloys) are auxetic ($V_{eff} < 0$); [2] when $7 \leqq x \leqq 11$ at.%Co, they are critical ($V_{eff} \fallingdotseq 0$); and [3] when $11 < x \leqq 23$ at.%Co, they are normal ($V_{eff} > 0$). Each point on the loading or un-loading curve was analyzed by the finite element analysis to show the side-view of the shear-stress (τ) distributions in the film, film/substrate, and substrate regions, respectively. We can study (or outline) the plastic-flow zone beneath the indenter by adopting the Tresca criterion: $\tau \geqq H/6$.

Biography

Jen, Shien-Uang has completed his PhD at the age of 29 from the Physics Department of Carnegie-Mellon University. He is now a senior research fellow of the Institute of Physics, Academia Sinica. He has published more than 123 papers in reputed journals.