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Modification of the mechanical properties of core-shell liquid gallium nanoparticles by thermal oxidation at low temperature

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Abstract-

Gallium nanoparticles (Ga NPs) are attracting increasing attention because of their appealing physical-chemical properties. In particular, their mechanical properties play a key role in the implementation of these core-shell structures on certain applications, such as soft and stretchable electronics. Thus, efforts are being addressed to modulate them mainly by chemical means. In contrast, this study investigates how the mechanical properties of the outer gallium thin oxide shell change when its thickness is increased through a thermal oxidation strategy. Specifically, as-deposited Ga NPs, as well as those subjected to thermal oxidation at 300 °C for three different times, are studied by performing single-particle indentations by atomic force microscopy over a wide range of NP radius. This analysis helps to confirm that the Reissner's thin-shell model for small deformations within the elastic regime is obeyed. From these data, the dependence of the shell stiffness and the Young's modulus of the gallium oxide on the thermal treatment is obtained. It is found that the shell stiffness increases with the annealing time, even by a factor of 50 under prolonged thermal oxidation, while the gallium oxide Young's modulus, close to 30 GPa, does not change significantly.

Index Terms-

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