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Size-dependent Elastic State of Embedded Nano-inclusions & Quantum Dots

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The classical formulation of Eshelby for embedded inclusions is revisited and modified to, at least partially, account for size-effects likely to be prominent at the nanoscale. In this two-pronged work, we firstly incorporate the previously excluded surface/interface stresses, tension and energies. The latter effects come into prominence at inclusion sizes in the nanometer range. Unlike the classical results, our modified formulations render the elastic state of an embedded inclusion size-dependent making possible the extension of Eshelby's original formalism to nano-inclusions. Presuming that, at least for some material systems, the inherent long-wavelength assumption of elasticity is violated for nano-size inclusion sizes, we also derive a modified Eshelby tensor in the framework of second gradient elasticity with couple stresses. Several applications of the present work are illustrated; in particular, the size-dependent strain state of quantum dots and the consequent effect on its optoelectronic properties along with limited empirical evidence are discussed.

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