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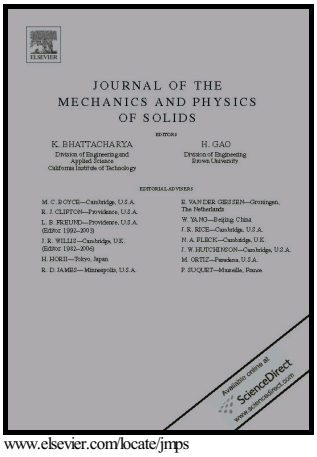


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# Universal Scaling Laws for Homogeneous Dislocation Nucleation During Nanoindentation

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We perform atomistic simulations to study the mechanism of homogeneous dislocation nucleation in two dimensional (2D) hexagonal crystals during nanoindentation with a circular indenter of radius $R$. We study both a realistic embedded atom method (EAM) potential for Al in addition to simple pair-wise potentials: Lennard-Jones, Morse, and Hookean springs. The nucleation process is governed by the vanishing of the energy associated with a single energy eigenmode. The critical eigenmode, or dislocation embryo, is found to be localized along a line of atoms with a lateral extent, $\xi$, at some depth, $Y^*$, below the surface. For all interatomic potentials, the scaled critical load, $F_c/R$, and scaled critical contact length, $C_c/R$, decrease to R-independent values in the limit of large $R$. However, despite this, $\xi/R$ and $Y^*/R$ display non-trivial scaling with $R$. We show that although both the interaction potential and the orientation of the lattice affect the prefactors in the scaling relations, all the scaling laws are robust. Furthermore, we show that a stability criterion proposed by vanVliet *et. al.* based on the minimum eigenvalue, $\Lambda$, of the local acoustic tensor predicts the location, orientation, and polarization of the dislocation embryo with a high degree of accuracy for all potentials and crystallographic orientations. However, we also show that, for all crystallographic orientations and interaction potentials, $\Lambda$ erroneously indicates instability before the true instability occurs.

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