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FCC金属塑性屈服的尺度效应和应变率响应

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摘要 对纳米尺度单晶铜的剪切变形进行了分子动力学(MD)模拟. 模拟结果表明，单晶铜的剪切屈服应力随模型几何尺度的增大而降低，而随着应变率的增大而升高. 基于位错形核理论，建立了一个修正的指数法则来描述面心立方(FCC)金属的尺度效应，该法则与较大尺度范围内(从纳米到毫米以上)的数值模拟结果以及实验数据都符合得比较好. 另外，MD模拟中发现单晶铜存在一个临界应变率，当施加的应变率小于该值，剪切屈服应力几乎不随应变率变化而变化；当大于该值，剪切屈服应力会随着应变率的增加迅速升高. 最后根据模拟的结果建立了单晶铜和单晶镍塑性屈服强度的应变率响应模型.

关键词 面心立方金属,尺度效应,率响应,塑性屈服应力

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Effects of specimen size and apllied strain rate on the plastic flow of FCC metals

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Abstract

The simple shear molecular dynamics (MD) simulations are performed on single-crystal copper blocks to analyze the size and strain rate effects on face-centered cubic (FCC) metals. It is found that the yield stress decreases with the specimen size and increases with the strain rate. Based on the theory of dislocation nucleation, a modified power law is established to predict the scaling behavior of FCC metals, and it agrees well with the numerical and experimental data ranging all spatial domain from nano-scale to macro-scale. In the atomistic simulation at different applied strain rates, a critical strain rate exists for the single-crystal copper. Below it the yield stress is nearly insensitive to the strain rate, while above it the yield stress increases rapidly with increasing strain rate. Based on the results of the MD simulation, a strain rate model is introduced for the plastic yield stress of FCC metals at nano-scale.

Key words FCC metals size effect strain rate effect plastic yield stress

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