From Discrete Dislocation Plasticity to a Statistical Model of Rough Surface Contact

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Abstract

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ABSTRACT BODY:
Abstract Body: It is well known that rough surfaces have asperities at a wide range of length scales; that contacting asperities may yield even under low loads; and that plasticity in crystalline metals is size dependent at length scales below tens of micrometers. The influence of size dependent plasticity on the contact and frictional properties, however, is still quite an open question.

Here we present a statistical description of rough surface contact that incorporates size dependent plasticity through a simple strain gradient plasticity theory. The intrinsic material length scale in the theory is obtained by fitting to two-dimensional discrete dislocation plasticity simulations of the flattening of a single asperity. The statistical model is an extension of the Greenwood-Williamson theory incorporating the interaction between asperities. The effectiveness of the statistical model is addressed by comparison with full-detail finite element simulations of rough surface contact using strain gradient plasticity. One of the most noteworthy results of the analysis is that contact force and total contact area remain linear, as for elastic materials, but with a proportionality factor that depends on the ratio of the rms roughness and the material length scale.