Why Static Friction Decreases From Single to Multi-asperity Contacts

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Abstract

The key parameter for describing frictional strength at the onset of sliding is the static friction coefficient. Yet, how the static friction coefficient at the macroscale emerges from contacting asperities at the microscale is still an open problem. Here, we present friction experiments of silicon-on-silicon contact, in which the normal load was varied over more than three orders of magnitude, so that a transition from a single asperity contact at low loads to multi-asperity contacts at high loads was achieved. We find a remarkable drop in static friction coefficient with increasing normal load, which can be captured by a simple stick-slip transition model, analogous to a fiber bundle model, based on the local normal contact stress map obtained from boundary integral contact calculations without adjustable parameters. We identify the presence of pre-sliding and subcritical contact points as the cause of smaller static friction coefficient at increased normal loads. Our measurements and model bridge the gap between friction behavior commonly observed in atomic force microscopy (AFM) experiments at microscopic forces, and industrially relevant multi-asperity contact interfaces loaded with macroscopic forces.

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