NANOSCALE DYNAMIC FRICTION AND WEAR MECHANISM OF ALPHA-QUARTZ ASPERITIES

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The frictional wear between fault surfaces commonly involves continuous deformation, fracture, or material removal on rugged projections (asperities), which can significantly influence the fault friction properties and energy dissipation during earthquakes. However, the current understanding of wear mechanism, especially at the microscopic scale, is limited to post-experiment analysis and empirical explanations due to the observation of the opaque wear process during frictional sliding. Here, we focus on the nanoscale wear process of two interlocked α-quartz asperities to explicitly reproduce a series of 3-D wear processes by employing molecular dynamics (MD). While the normal force and velocity-dependent dynamic wear damage mechanism was observed, the empirical wear model for volume loss (Archard law) was also compared to discuss the multi-scale applicability. Our findings indicate that the wear attrition mechanism on asperities is less influenced by the loading velocity but governed by the normal force. Under the low normal force, worn atoms are primarily from the bonding and shear traction between interfacial atoms. In contrast, a significant plastic flow by layered shear motion dominates under the high normal force and atoms are more prone to be detached as clusters. Higher normal force corresponds to larger scale clumps of attrition on asperities. Notably, adhesive wear dominates in all results. In addition, the empirical wear model (Archard law) shows some limitations in quantifying the wear volume due to the effect of increasing loading velocity. Instead, the friction work, with considering an instantaneous friction coefficient and a time-varying contact force, could predict the wear volume accurately.