Atomic Precision Material Removal Using AFM under Electric Fields

Ning Huang, Zhichao Geng, Marco Castelli and Fengzhou Fang#

Centre of Micro/Nano Manufacturing Technology (MNMT-Dublin), School of Mechanical & Materials Engineering, University College Dublin, Dublin 4, D04V1W8, Ireland
Corresponding Author / Email: fengzhou.fang@ucd.ie

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The ultimate goal in manufacturing precision is atomic accuracy, which leads to atomic and close-to-atomic scale manufacturing. To meet this future demand and vision, we explored the possibility of achieving material removal with atomic precision using Atomic Force Microscopy (AFM). The study revealed that under the application of an external electric field, the AFM probe can not only induce surface oxidation, resulting in nanometer-scale protrusions—widely known as local anodic oxidation—but can also achieve single-layer atomic depth material etching and removal. The contrasting phenomena of protrusion formation and etching suggest the presence of a material removal mechanism fundamentally different from anodic oxidation under the influence of an electric field. Preliminary analyses were conducted using Density Functional Theory (DFT) to gain some atomic insights into the atomic-scale material removal mechanism under the energy field. This research paves the way for new methodologies in nanofabrication, contributing significantly to the advancement of nanoscience and manufacturing science.