Local modification of Ag thin films on Si(100) by scanning tunneling microscopy

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20-nm-thick Ag films, deposited on UHV-cleaned Si(100) surfaces, can be substantially modified with a scanning tunneling microscope used in an oscillatory mode with junction voltages above +3 V-+4 V and currents between 0.1 and 30 nA. During modification, the tip-surface junction is quite unstable, with repeated instabilities leading to vertical tip motions of up to 150 nm in amplitude. Material is drawn toward the tip, leaving on the surface about 100-nm-high cones with a base diameter of approximately 150-300 nm that are surrounded by 50-100-nm-wide areas, where the bare substrate is exposed. Upon moving the tip across the surface, arbitrary lines can be written into the film. The width of the created surface structures increases linearly with increasing junction voltage from 4-9 V, and logarithmically when increasing the current from 30 pA to 30 nA. The experimental data suggest that the modification process is caused by an electronic field emission out of the tip, leading to heating and melting of the Ag film locally underneath the tip. At voltages of 4-8 V an unstable switching between field emission and tip-sample contact with a formation of a liquid-metal neck in the junction results in large-amplitude tip oscillations.