

## **On the nanoscale measurement of friction using atomic-force microscope cantilever torsional resonances**

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We studied friction and stick-slip phenomena on bare and lubricated silicon samples by measuring the torsional contact resonances of atomic force microscope cantilevers. A piezoelectric transducer placed below the sample generates in-plane sample surface vibrations which excite torsional vibrations of the cantilever. The resonance frequencies of the vibrating beam depend on the tip-sample forces. At low lateral surface amplitudes the cantilever behaves like a linear oscillator with viscous damping. Above a critical surface amplitude, typically 0.2 nm, the amplitude maximum of the resonance curves does not increase any more and the shape of the resonance curves changes, indicating the onset of sliding friction. The critical amplitude increases with increasing static cantilever load. For a bare silicon sample it is higher than for the lubricated silicon. Microslip known from macroscopic contacts causes energy dissipation in the atomic force microscope tip-contact before sliding friction sets in.