Voice coil based scanning probe microscopy

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Since its invention, scanning probe microscopy (SPM) is closely related to actuators based on the piezoelectric effect. SPM scanners using piezoceramic components are able to provide positioning in the range up to tens of micrometers with subatomic resolution. There are, however, some principal disadvantages of using piezoceramic components. First of all, they exhibit many unwanted mechanical and electrical properties (creep, hysteresis, etc.). These effects can be partially compensated using feedback loops based on independent displacement sensors. Second, they have limited actuation range and they need a high voltage for its operation. This limits the use of piezoceramic components in many applications, namely in the field of coarse positioning. Every nowadays SPM system needs to have both coarse positioning system (using e.g. servo motors) and fine positioning system, using piezoceramic components.

As an alternative, actuation based on voice coil motors can be used. In this contribution we show that voice coil based actuation combined with interferometry can be a good alternative to piezoceramic positioning systems, providing fast and still enough precise displacement in the range from nanometers to millimeters. This is a key prerequisite for developing novel generations of SPMs that would combine very large range with high speed imaging. We will show that systems using voice coil actuators can use only single positioner for both coarse and fine tip/sample movement, can use only low voltage electronics and can naturally provide metrology data of high accuracy. Moreover, electromagnetic actuation can be naturally used also for small force generation, that can be used for probe displacement controlled measurements in SPM and for nanoindentation. In the contribution we will discuss the positioning resolution, dynamic properties of voice coil systems and influence of mechanical properties of linear guiding system on speed of the SPM scanner. Illustrative SPM measurement results will be shown on typical SPM calibration samples and microelectronic chip surface structures.