Scanning Proximal Probes for Parallel Imaging and Lithography

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In last 20, years Scanning Proximal Probes Technology (SPPT) has become a major instrument for research in biology, chemistry, materials science, and physics as well as in semiconductor industrial applications. Transforming SPPT technology from a research instrument into a viable tool for large-scale applications requires performance improvements. Advancement in micro technology during the last 10 years has pushed the development of new proximal probe techniques for measurement and testing of tiny microelectronic devices. In most cases, sub-nanometer topographical resolution is required. SPM is a powerful technique which fulfils these requirements. Moreover, nowadays the nanoprobes themselves are mechanically, physically, chemically or biologically functionalized for specific physical, chemical or biological applications at high spatial resolutions.

The progress of this technique began with the invention of the scanning tunnelling microscope (STM) by Binnig and Rohrer in 1981. Based on these principles and following the pioneering work of Christie Marrian (at that time, from IBM), the group of Cal Quate at Stanford developed the first parallel proximal probe lithography system while the team of Peter Vettiger from IBM developed SPP devices called “Millipede” for nanomechnical data recording.

In this paper we describe our approach for increasing the speed of SPP systems using cantilever arrays for parallel operation of self-actuated piezoresistive cantilevers and employing a fast scanning stage. The essential advantage in this SPP development is the mechanical response transaction based on the piezoresistive principle. Probe interactions with the environment, which cause a change of cantilever resonance frequency, phase shift, or bending, can be detected extremely fast and make SPP well suited for real-time monitoring. They offer the possibility of operation in vacuum and as parallel SPP systems. The feedback speed can be improved through integration of the actuator with the cantilever providing a feedback directly by applying active force to each cantilever. The micro-actuators integrated on every cantilever are based on the so-called bimetal effect. This causes the resonance frequency to be much higher compared to the normally used piezoelectric-actuator stage in commercial systems. A parallel self-actuated and self sensing cantilever-probe platform packaged as a VLSI NEMS-chip (Very Large Scale Integrated Nano Electro Mechanical System) incorporating 128 proximal probes, fully addressable with control and readout interconnects and advanced software for parallel imaging and lithography will be presented. This work was done together in collaboration with 18 partners in the frame of the PRONANO-Project and was founded by the European Commission (FP6th).