Tip-based Nano-Manufacturing and -Metrology

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The state-of-the-art optical lithography approach, designated for high-volume production, requires application of highly sophisticated fabrication equipment. For beyond CMOS applications alternative technologies of nanofabrication are drawing more and more attention. Among many solutions scanning probe-based methods for lithography are the emerging technologies for manufacturing of sub 10-nm features for future nanoelectronics and beyond CMOS solutions[1],[2]. Today's scanning probe lithography (SPL) approaches are based on atomic force microscopy (AFM) systems, characterized by positioning range of the order of 100 µm x 100 µm. In order to fabricate structures of single nanometer dimensions localized with fraction of nanometer resolution SPL process must be controlled with very high precision, allowing sub-nanometer positioning accuracy for all three axis, minimized nonlinearity errors and high scanning speed of up to mm/s. Moreover, cantilever array setup increases the measurement and nanostructure fabrication throughput and makes it possible to operate over large scanning arrays[3]. It must be noted however, that SPL for beyond CMOS applications requires positioning, placement, metrology and inspection uncertainties defined in the range of nanometers in combination with x-, y- travel ranges of several millimeters[4] . The presented above requirements can be solved by the nanopositioning and nanomeasuring machine (NPM) based technology [5]. The NPM tip-based fabrication makes it possible to fabricate and measure features in the field of 25 mm × 25 mm × 5 mm with sub-nanometer resolution and accuracy. Moreover, if SPL and NPM technologies are combined not only direct nanostructure fabrication in a positive-tone lithography but also their inspection can be done without any steps in between. In this talk we will describe the combination of the NPM and tip-based-manufacturing, enabling large area pattern generation in closed loop lithography[5] and high accuracy metrology will be also discussed.

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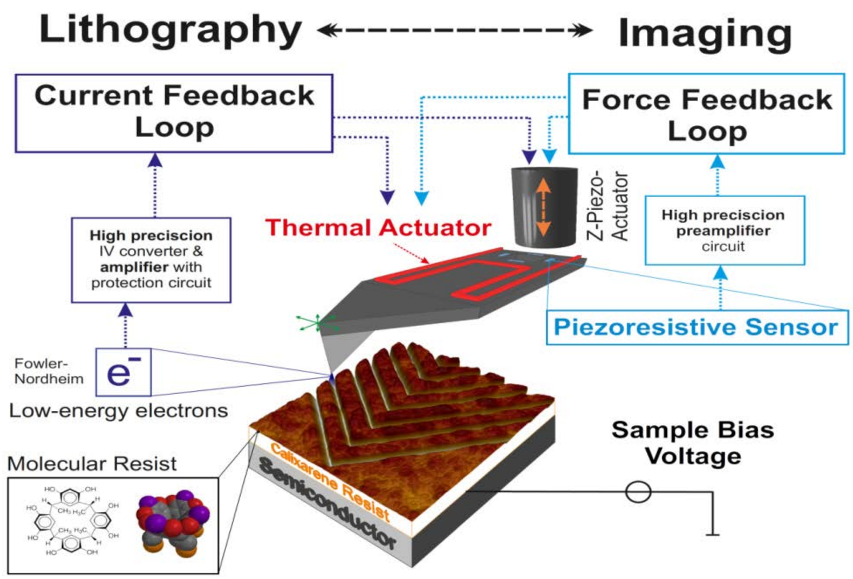

Figure 1: Schematic layout of the Imaging & Lithography NMP and SPL system. The same nano-probe is used for both direct writing of nano-features using spatially confined low-energy electron emission from nano-probe-tip and AFM-imaging for pre- and post-inspection as well as for pattern overlay alignment [5].

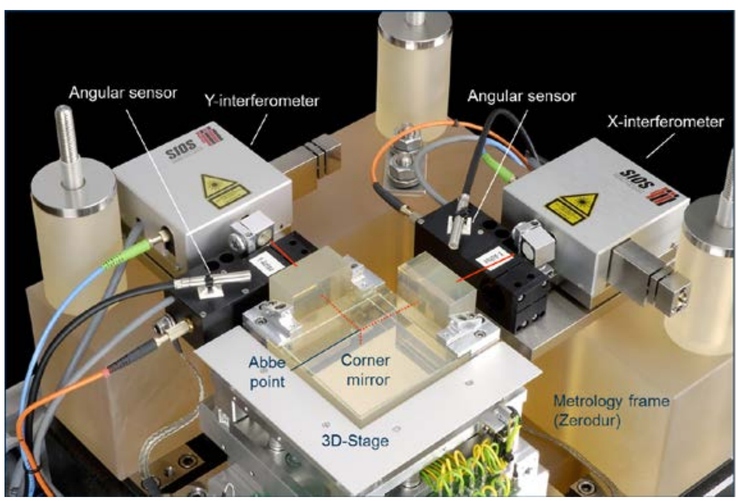

Figure 2: NPM tip-based fabrication and nanometrology machine with 20 pm resolution; < 100 pm multi-axis stability: capability for environmental influences with scanning range: 25 mm x 25 mm x 5 mm [4].