FUNCTIONAL NANOSTRUCTURE FORMATION BY FOCUSED PARTICLE BEAMS

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Focused Particle Beam systems rely on a scanning microprobe technique similar to a Scanning Electron Microscope (SEM). In contrast to a SEM, however, both types of particles, ions or electrons, can be rastered over a surface for surface modificaton. Since the beam extension can be focused to a few nanometer, surface modifications well beyond the state of the art of lithography can be made. Moreover, the beam correlated secondary electrons can be used to image simultaneously the target area under irradiation, thus surface offering direct control of the modifications on a nanometric scale. The focused particle beam functionalities issue ion or electron beam interactions with a target surface in a vacuum or a predefined gas atmosphere. Due to its strict confinement, nanoscale level research and development is the dominant application.

Application of Focused Beams cover a wide range of activities, from basic ion-surface interaction research, over local processing for removal or deposition of layers, up to device fabrication and 3-D-nanofabrication. Since the knowledge of the correct beam profile at the target surface is crucial to any proper solid-beam interaction investigation, our group developed an approach to extract the specific beam profile by a material insensitive approach [1]. Any application of a beam approach in a complex processing scheme like microelectronics, however, is endangered by radiation damage. Therefore, we applied an in situ approach to quantify the impact of a focused Ga beam to specific electronic device parameters during beam exposure. We found that progressive degradation of the device starts only when long-range damage cascades begin to extend into the inversion channel regions of a MOSFET. Premature device breakdown could be attributed to electric discharge, thus can be avoided by faraday shielding. The device degradation due to exposure could be attributed to inversion charge mobility deterioration in the channel region, and – more important - could be quantified in a semi-empirical mobility model [2]. Thus, focused ion beam damage is not prohibitive to device level engineering.

Recently, quantum dots and nanowires have gained much interest, since they promise solutions for the foreseeable onset of the quantum regime at downscaled devices. In this nanoscale fields, focused particle beam processing is a favorable choice, due to its combination of maskless patterning with nanoscale critical dimensions. Accordingly, we developed focused ion beam based techniques for the synthesis of nanowires with diameters of 20 nm and less. In contrast to a broad class of actual techniques neither heating of the sample nor any extra material source is required for a nanowire evolution on substrates like Ge, Sb, GaSb [4], thus this approach is promising for on-chip processing in micro- and nanoelectronics, and in integrated sensorics. The field of catalysed nanowire growth is an additional, future-oriented field of nanotechnology, requiring nanoscaled pure metal aggregations at predefined sites, preferably in an arbitrary array. However, ion beam constituents inherently tend to poison the catalysts. So, to cope with this problem, focused electron beam assisted deposition of metal catalysts for a subsequent nanowire or nanodot growth is a primary choice and enables directly written templates for nanowire arrays.

References:

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