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Ion Beam Patterning at the Nanometer Scale

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Due to the absence of diffraction limitations, the extensive available process parameter space, and the prospects for one-shot imposition of a projection-reduced master mask pattern, ion beam patterning appears to offer a viable path to large-scale manufacturing of devices and systems based on nanoscale features, while offering robustness, flexibility, high quality of image definition and high throughput. We will review a variety of process variables, and the strategies by which they can be optimized for a specific application, in terms of resolution of the smallest features, minimal proximity effects, minimal edge effects, minimal statistical noise, high dimensional stability and pattern registration, and minimal effects on underlying layers. We use SRIM and other simulations of ion interactions to model the effects of ion species, energy, fluence and beam current density, and their impact on the choice of mask structure and type of photoresist where appropriate. We consider the application of the ions to pattern photoresist layers, or to locally modify the topography of polymer films, or to locally activate surfaces for selective adsorption. We also consider options for in-situ growth of 3D nanoscale features. Direct modification of the interfaces of thin film structures, and local ballistic disordering will also be discussed. Experimental demonstrations of low energy ion beam patterning with $<$40 nm resolution will include contact mask patterning of thin films of various polymers, and patterning of high-anisotropy magnetic multilayers for high storage density disk drive applications.