NanoFrazor Lithography for advanced 2D and 3D Nanodevices

Authors : Zhengming Wu

Abstract : NanoFrazor lithography systems were developed as a first true alternative or extension to standard mask-less nanolithography methods like electron beam lithography (EBL). In contrast to EBL they are based on thermal scanning probe lithography (t-SPL). Here a heatable ultra-sharp probe tip with an apex of a few nm is used for patterning and simultaneously inspecting complex nanostructures. The heat impact from the probe on a thermal responsive resist generates those high-resolution nanostructures. The patterning depth of each individual pixel can be controlled with better than 1 nm precision using an integrated in-situ metrology method. Furthermore, the inherent imaging capability of the Nanofrazor technology allows for markerless overlay, which has been achieved with sub-5 nm accuracy as well as it supports stitching layout sections together with < 10 nm error. Pattern transfer from such resist features below 10 nm resolution were demonstrated. The technology has proven its value as an enabler of new kinds of ultra-high resolution nanodevices as well as for improving the performance of existing device concepts. The application range for this new nanolithography technique is very broad spanning from ultra-high resolution 2D and 3D patterning to chemical and physical modification of matter at the nanoscale. Nanometer-precise markerless overlay and non-invasiveness to sensitive materials are among the key strengths of the technology. However, while patterning at below 10 nm resolution is achieved, significantly increasing the patterning speed at the expense of resolution is not feasible by using the heated tip alone. Towards this end, an integrated laser write head for direct laser sublimation (DLS) of the thermal resist has been introduced for significantly faster patterning of micrometer to millimeter-scale features. Remarkably, the areas patterned by the tip and the laser are seamlessly stitched together and both processes work on the very same resist material enabling a true mix-and-match process with no developing or any other processing steps in between. The presentation will include examples for (i) high-quality metal contacting of 2D materials, (ii) tuning photonic molecules, (iii) generating nanofluidic devices and (iv) generating spintronic circuits. Some of these applications have been enabled only due to the various unique capabilities of NanoFrazor lithography like the absence of damage from a charged particle beam.

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