Plasmonic Nano-Disks Arrays made with EBL using the Dots-On-The-Fly Method

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Plasmonics and metamaterials have attracted considerable attention over the past decade, owing to the revolutionary impacts that they bring to both the fundamental physics and practical applications in multiple disciplines. These structures are routinely patterned by Electron Beam Lithography (EBL). For practical application, a large surface area coverage by uniform nanostructures is required. Therefore, accelerating EBL patterning speed for these structures will pave the way towards more practical applications.

Fabrication of large arrays with traditional EBL techniques is cumbersome during pattern design, usually leads to large data files and easily results in system memory overload during patterning. In Dots-on-the-fly (DOTF) patterning, instead of specifying the locations of individual spots, a boundary for the array is given and the spacing between spots within the boundary is specified by the beam step size. A designed pattern element thus becomes a container object, with beam spacing acting as a parameterized location list for an array of spots confined by that container. With the DOTF method, a single pattern element, such as a square, rectangle or circle, can be used to produce a large array containing thousands of spots. Experimental demonstration of DOTF patterning in this work was done using a 50 kV electron beam with a current of ~20 pA. Patterns were exposed in ~100 nm thick CSAR 62 positive e-beam resist with area doses ranging from ~25 μC/cm2 up to ~90 μC/cm2. Patterns were developed in ZEP developer, rinsed in IPA and dried under nitrogen flow. The Metal coatings were deposited by e-beam evaporation and Microposit 1165 remover at 80 °C was used for lift-off with final rinse in acetone.

DOTF is an ideal method to speed up writing plasmonic arrays. Figure 1 shows a SEM (Scanning Electron Microscope) micrograph of a plasmonic disk array made by using the DOTF method. The narrow area-size distribution of the nano-disks is plotted in Figure 2. Figure 3 shows the optical reflectance spectra from three arrays. We will compare write speeds, optical spectra, and uniformity of plasmonic arrays made by traditional EBL and DOTF.

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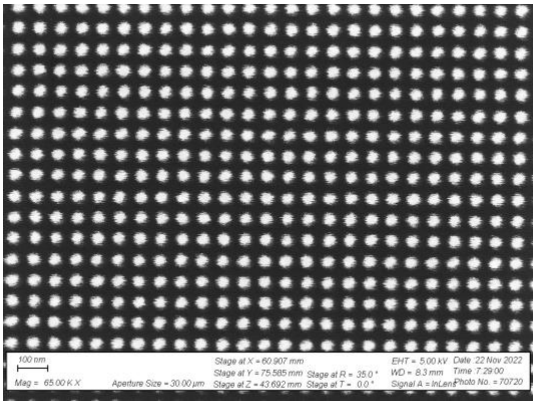

Figure 1: SEM micrograph: A dense array of Ti/Au (1/20 nm) nanodisks on silicon,fabricated with the DOTF method.

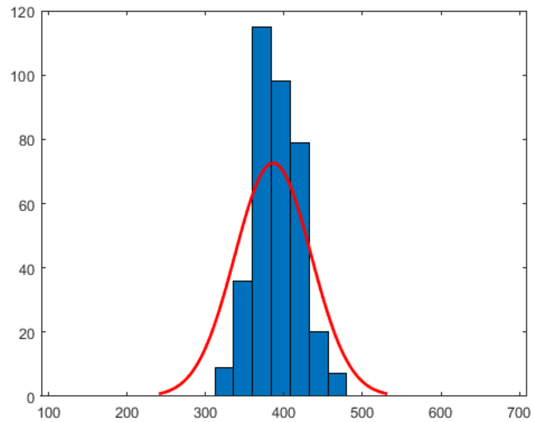

Figure 2: Size distribution: This is the pixel-area size distribution from the SEM in Figure 1, showing a narrow size range for the nano-disks.

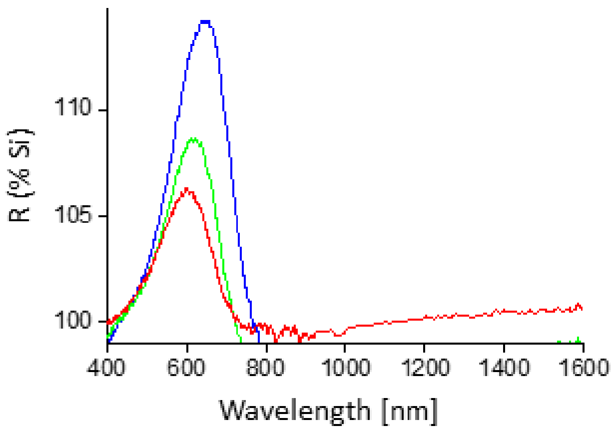

Figure 3: Reflectance spectra from Ti/Au plasmonic nano-disks array: These are reflectance spectra from three plasmonic Ti/Au arrays on Si written with the DOTF method. The pitch is 70 nm for all arrays, and different plot color correspond to different exposure dose, resulting in different disk diameters.

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