Patterning large area plasmonic nanostructures on non-conductive substrates using variable pressure electron beam lithography

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Tuning properties of optical devices consisting of plasmonic nanostructures for visible light often involves use of non-conductive substrates. Unfortunately, patterning electrically-insulated substrates using electron beam lithography is challenging due to the need of proper charge dissipation. Several techniques such as deposition of conductive layer or critical energy matching (CEM) were developed in the past[1]. However, this processing increases the fabrication cost and introduces fabrication difficulties due to the need of layer removal after the exposure or limits exposure conditions (CEM).

Our research is focused on variable pressure electron beam lithography (VP-EBL).[2] VP-EBL is based on the introduction of residual N_2 gas atmosphere in the specimen chamber in order to create positive ions to balance negatively charged sample surface. The main advantage of our approach is no need of any sample pre-exposure or post-exposure treatment.

As a demonstration of our method, we have fabricated large areas of plasmonic nanoantennas (Figure 1) on a glass substrate using variable pressure SEM TESCAN Mira 3 and DrawBeam pattern generator. Thanks to the localized plasmon resonance, various color effects of fabricated structures can be observed. In order to get a well defined color of structures, it is necessary to precisely tune the dimensions of fabricated structures with diameter error below 10 nm. Figure 2 shows that VP-EBL process is stable enough to carry out long time exposures and enables fabrication of color images on glass substrate at large-scale. The fabricated structures were further characterized and correlated using the transmission spectroscopy techniques (Nanonics multiview system with Andor Shamrock spectrograph) and coherence-controlled holographic microscopy[3] (TESCAN Q-PHASE).

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2 B. Myers and V. Dravid, Nano Letters 6, (2006).

3 T. Slabý, P. Kolman, Z. Dostál, M. Antoš, M. Lošťák and R. Chmelík, Opt. Express 21, (2013).

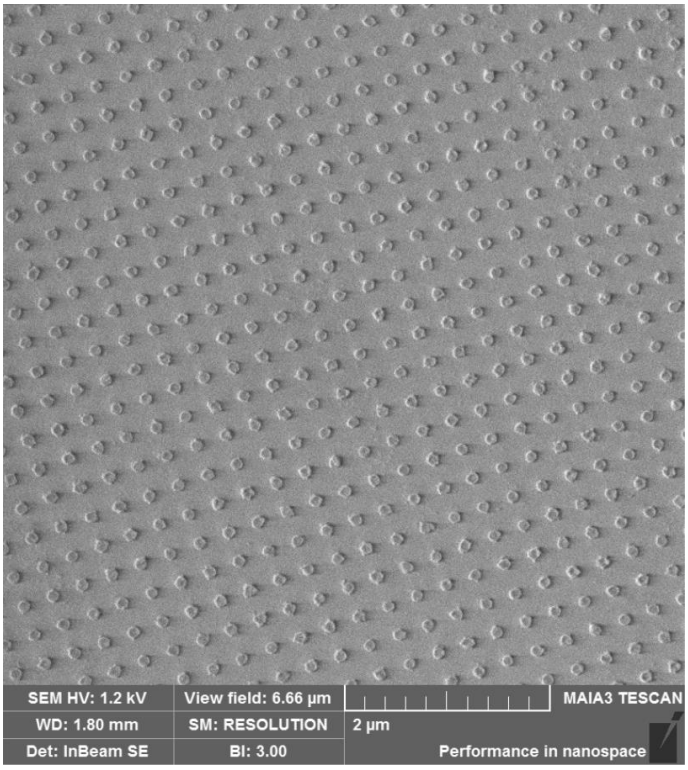

Figure 1: SEM image of fabricated structures (nanodisc arrays) after silver deposition and lift-off.

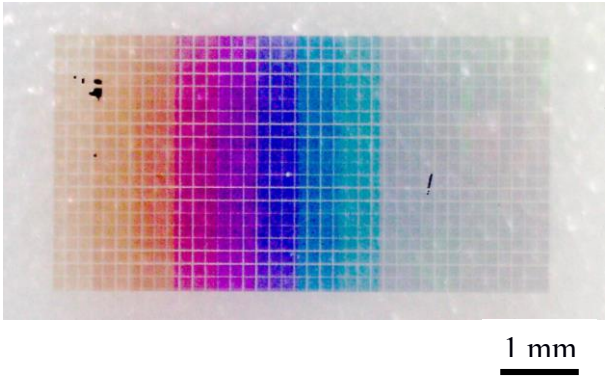

Figure 2: Large area plasmonic image patterned on glass substrate imaged by transmission light microscopy.