# FIB Nanofabrication with Sketch & Peel Method: Employing non-Ga Ion Species for Plasmonic Arrays

H. Duan, Y. Chen, K. Bi
*College of Mechanical and Vehicle Engineering, Hunan University, Changsha 410082, People's Republic of China*

S. Bauerdick, A. Nadzeyka, M. Kahl
*Raith GmbH, Konrad-Adenauer-Allee 8, 44263 Dortmund, Germany*
*sven.bauerdick@raith.de*

Focused ion beam (FIB) systems are valuable tools for nanofabrication and rapid prototyping tasks in R&D by providing direct, resistless, and three-dimensional patterning. Although FIB milling in many cases is slower than a resist based process, the relative simplification of the overall nanofabrication approach helps to achieve scientific results faster. We have reported before that with a lithographic instrument design it is possible to perform write field stitching as well as truly continuous writing strategies for advanced FIB nanofabrication.
Moreover we have shown the extension in FIB technology of employing a liquid metal alloy ion source (LMAIS) towards the stable delivery of multiple ion species selectable by a mass separation filter. This is incorporated into the column to allow for fast and easy switching between different ions with an overall design preserving sub-10 nm beam resolution [1].

To extend the capabilities of FIB nanofabrication, the method of sketch & peel has been recently proposed for direct patterning of thin gold films [2]. With this method, FIB milling is able to create isolated metallic structures that are difficult to fabricate by conventional subtractive milling process. Considering that isolated metallic structures [3] are more favorable for investigating some optical properties but usually lead to unacceptable time-consuming processes by removing most of the gold layer, the sketch & peel method is supposed to be substantially useful for FIB nanofabrication applications.

In this work we further investigate FIB sketch & peel method for nanopatterning of thin gold layers with Au and Si focused ion beams and compare the different ion species in terms of process and results (Figures 1 and 2). This technique is applied to different plasmonic patterns showing advantages and limits in contrast to complete direct milling. Moreover field stitching as well as continuous writing strategies, *i.e.* combined movement of beam and stage, are presented for plasmonic arrays exceeding a single writing field (Figure 3). The feasibility of

FIB sketch & peel method for large area patterns and related challenges like patterning/ removal homogeneity and layer quality will be discussed as well.

[1]S. Bauerdick et al., JVST B 2013, 31, 06F404.
[2]Y. Chen et al., ACS Nano 2016, 10, 11228-11236.
[3]M. Hentschel et al., Nano Lett. 2010, 10, 2721-2726.

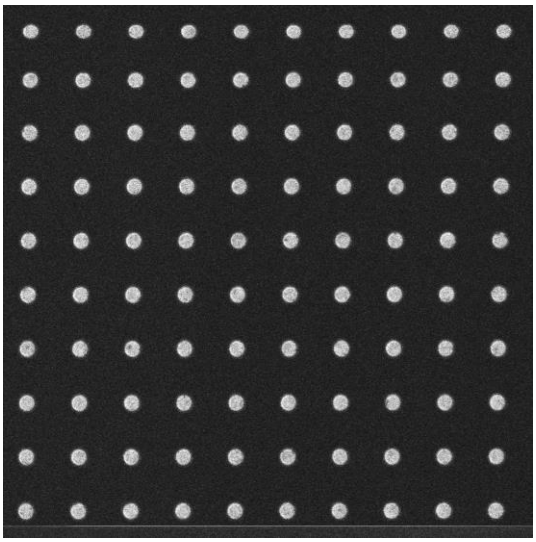

*Figure 1:* An array of gold circles created by sketch & peel nanofabrication while using a focused **Au ion** beam for milling the outline (pitch 2 µm).

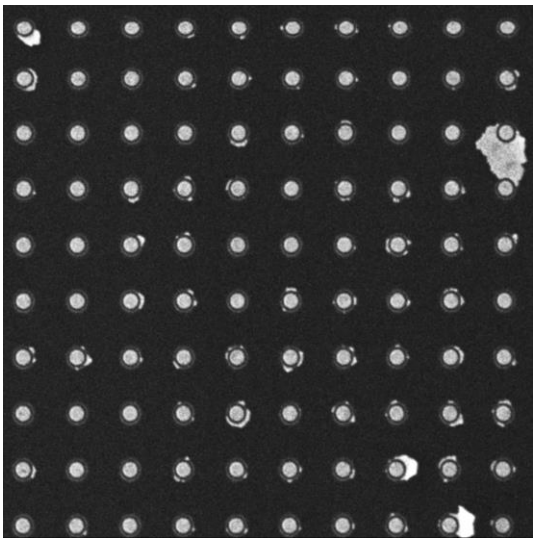

*Figure 2:* An array of gold circles created by sketch & peel nanofabrication while using a focused **Si ion** beam for milling the outline (pitch 2 µm).

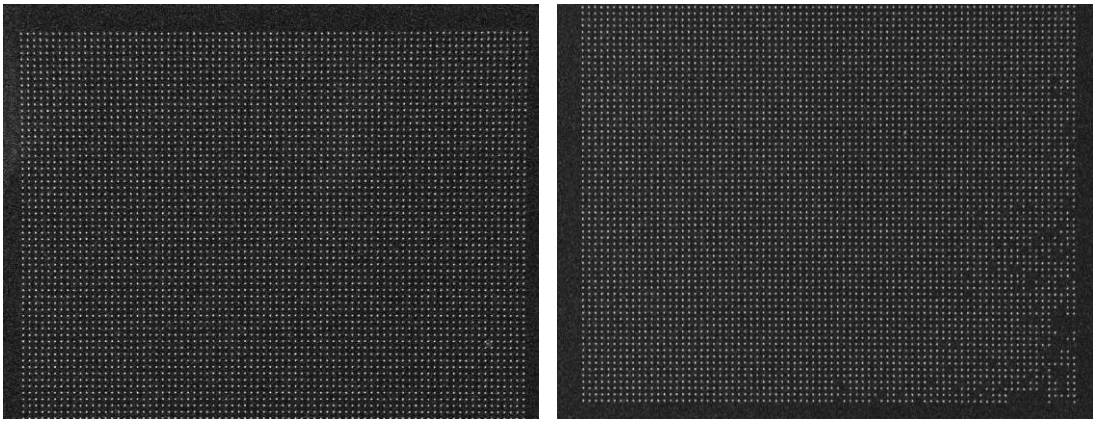

*Figure 3:* A 200 µm wide and 1 mm long array of circles created by sketch & peel method in a gold layer with a focused Au++ ion beam. Different number of defects can be observed at the pattern start/ end or sample locations.