Automated overlay with the NanoFrazor

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The NanoFrazor uses thermal scanning probe lithography (tSPL) for patterning and inspection of nanoscale structures as well as direct laser sublimation (DLS) for mix & match lithography to create nanodevices. The technology solves complex fabrication challenges by providing a way to achieve accurate markerless overlay, sub-nanometer precise 3D grayscale lithography, and the ability to integrate into inert atmospheres. The latter allows the further growth of the NanoFrazor into applications using sensitive material classes, which also benefit from this non-invasive technique with damage-free patterning capabilities.

Automation of the lithography steps carried out by the NanoFrazor is a natural next step in the expanding application space where the tool is used. In addition to making workflows for nanoelectronic device fabrication reliable and repeatable, and allowing unattended operation, automation is also a valuable training tool for novice users. Scripting functionality and unprecedented patterning endurance make automated, markerless overlay of arbitrary structures possible. Applications where high-resolution, critical features must be placed precisely on pre-existing structures (e.g. nanopillars on micro-posts, defined channels between FinFET source and drain contacts, …) benefit directly from this lithographic approach.

Here we present successfully implemented use-cases of automated, markerless overlay with the NanoFrazor, including nanopillars centered on pre-patterned matrices of microstructures. The overlay is shown to work even when the underlying structures are buried under resist layers, thanks to the highly sensitive in-situ reading capability of the tool. Using multiple reference points to calibrate for rotation and scaling errors on the substrate, the NanoFrazor software remains independent of the substrate placement and accuracy of the previous lithography steps. Once the substrate location and calibration are completed, design layouts of arbitrary shapes can be overlaid, patterned and simultaneously inspected, as shown in Figure 1. The inspection allows users to validate that the patterning has been carried out at the correct location and with a sufficient depth in the resist for subsequent processing. A lift-off step to produce the desired nanopillars on the micro-posts was validated using AFM and SEM imaging upon completion, as shown in Figure 2.

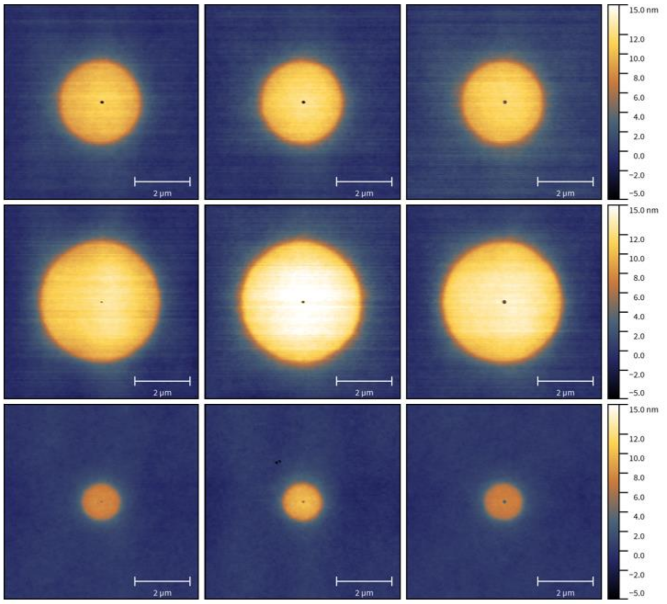

Figure 1: Example of automated overlay with the NanoFrazor, where a nanoscale circle was patterned in the center of a pre-existing micropillar in a repeated matrix. The circle is visible as a dark dot in the center, due to being created by sublimating thermal resist locally.

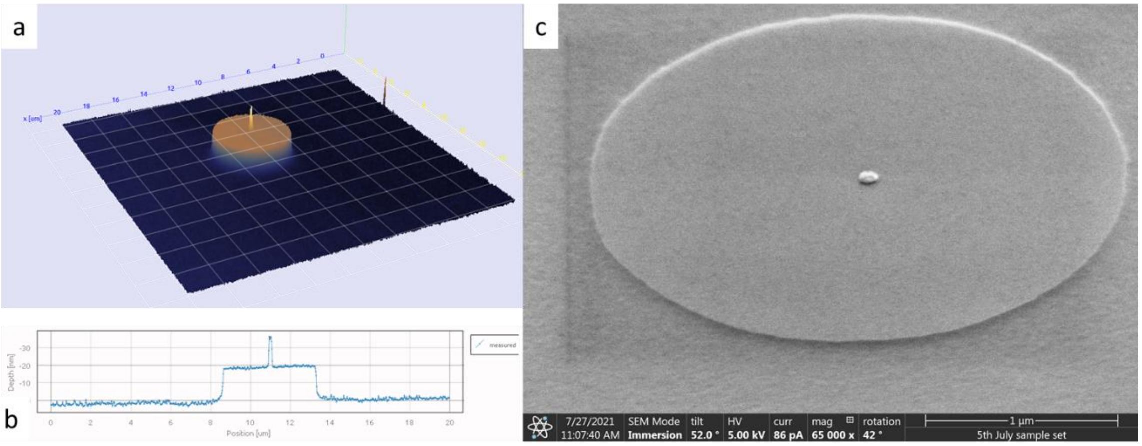

Figure 2: Characterization of nanopillars on micropillars through AFM, shown in 3D (a) and in profile (b). SEM micrograph of a nanopillar patterned at the center of a 2.5 µm high micro-post. The structures were obtained by lift-off processing following thermal scanning probe lithography with the NanoFrazor.