Thermal scanning probe-based greyscale nanopatterning applied to 2D materials

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Abstract

Thermal scanning probe lithography (t-SPL) that uses a heated AFM probe to induce locally thermal phase changes in materials has become a reliable nanolithography tool [1]. One distinct advantage of t-SPL is that it does not involve charged particle and resist development steps, thus enabling the patterning of fragile materials systems that would otherwise fail by conventional lithography methods. One further benefit of t-SPL is its excellent grey-scale patterning capabilities, thanks to the inherent closed-loop AFM-type of writing and reading. Such surfaces are of interest in photonics and nanofluidics, but also in the field of 2D material strain engineering.

This paper will present an overview of the current state of the art in t-SPL and probe design, and will show recent results obtained for t-SPL based deterministic patterning and straining of 2D materials [2, 3]. The latest improvements in a key nanomanufacturing step related to pattern transfer by dry etching from the thermal resist PPA into solid dielectrics such as SiO_2 is also shown [4].

References

[1] S. Howell et al. Thermal scanning probe lithography – a review; *Microsystems & Nanoengineering* (2020)
[2] X. Liu et al. Thermomechanical Nanocutting of 2D Materials, *Advanced Materials* (2020)
[3] X. Liu et al. Thermomechanical Nanostraining of Two-Dimensional Materials, *Nano Letters* (2020)
[4] B. Erbas, et al. Combining thermal scanning probe lithography and dry etching for grayscale nanopattern amplification, *ChemRxiv* (2023)

Figures

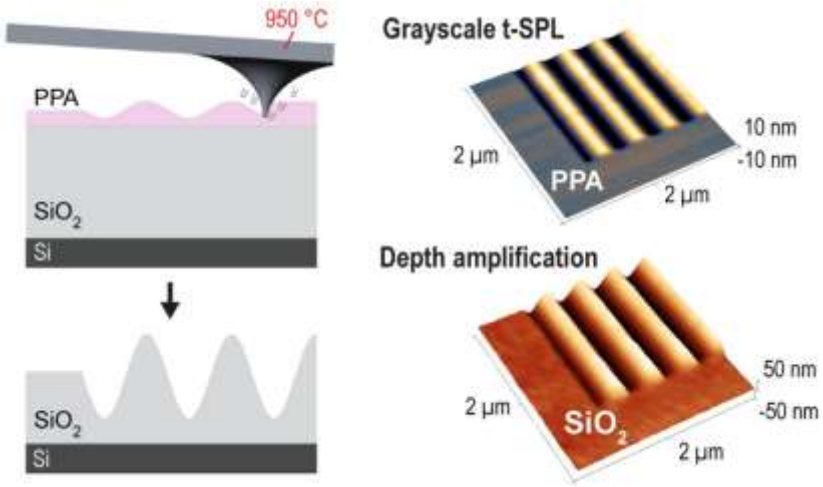

Figure 1: Schematics (left) and AFM profiles (right) of t-SPL patterns after writing in PPA and after etch transfer into SiO2. The sinusoidal surface profile can be amplified without shape distortion and without increasing surface roughness.