Controlled Plowing-Induced Nanostructuring and Particle Release on Polystyrene Surfaces

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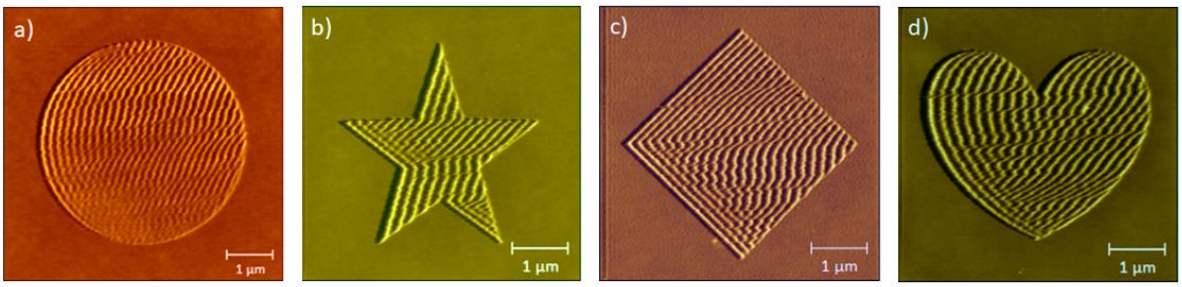
We report the formation of spherical nanoparticles on polystyrene surfaces by atomic force microscopy tips repeatedly scratched along a series of parallel lines [1]. The particles nucleate from the crests of the wrinkles formed in the early stages of the scratch process. As proven in accompanying studies with different scan patterns, including square, circular, rhombic, and heart-shaped areas [2], the wrinkles are well-reproduced by applying the Prandtl model originally developed for atomic-scale friction to a variable energy landscape built up by the tip elastically driven on the compliant surface and periodically indenting it viscoplastically [2-4]. As the scan is repeated, the nanoparticles are detached and progressively displaced across the wrinkles till the edge of the scanned areas, where they pile up without coalescing. The detachment is smooth, and the absence of static friction peaks suggests that the particles are torn off by means of a crazing mechanism caused by the tip pushed against the wrinkle crests. Considering the negative environmental and health impact of these phenomena, our results may trigger new quantitative characterization methods of plowing wear on different polymeric materials of technological relevance at single particle level.



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