Implementation and Characterization of Tunable Reconfiguration and Actuation in Microbowls using atomic force microscopy

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ABSTRACT

The atomic force microscopy (AFM) is an extremely powerful tool for the characterization and manipulation of biological samples and microdevices in the life sciences and biomedicines [1, 2]. Here we aim at increasing the programmability on micro-objects using atomic force microscopy (AFM) to allow a sequential actuation at different geometrical level on demand. In this study, temperature-memory polymer based micro-cuboids were designed and fabricated as a model system [1, 3]. The actuation should occur on the microscopic cuboid level as well as on nanoscale changes of cavities implemented on the microcuboid´s top surface. The programming of the microcuboid was achieved by compression between glass slides with an external force or indentation using AFM on the surface at certain programming temperatures T_{prog}. Micro-bowls were realized by indentation using a spherical tip on the surface of the microcuboid to achieve temporary nanocavities with defined depth and pattern at different T_{prog}s. The geometry and surface structure of the microcuboids was analyzed from AFM height images. By varying T_{prog} and the sequence in the procedure, the stepwise actuation on nanocavities and whole micro-bowl can be realized with reversible actuation of 2-6%. Besides, multiple nanocavities can be generated on the same micro-bowl to achieve sequential recovery and actuations by designing stepwise programming at different T_{prog}. Finally, a demonstration of micro-bowl trapping and sequential elevating submicron particles was performed to proof the concept as on-demand carriers. The technology presented in this work can inspire the further design of multifunctional micro-objects in order to fulfill complex tasks with actuation functions on the micro/nano-level.

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2. Nie, Y., et al., *The response of human induced pluripotent stem cells to cyclic temperature changes explored by BIO-AFM.* MRS Advances, 2021. **6**(31): p. 745-749.
3. Liu, Y., et al., *Polymeric Microcuboids Programmable for Temperature-Memory.* Macromolecular Materials and Engineering, 2020. **305**(10): p. 2000333.