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Optically Actuated Soft Microrobot Family for Single-cell Manipulation

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Precisely controlled manipulation of non-adherent single cells is often a pre-requisite for their detailed investigation. Optical trapping provides a versatile means for cell manipulation with sub-micrometer precision. Indirect optical trapping enables cell manipulation with no photodamage and superior spatial control and stability by relying on optically trapped microtools attached to the cell. 3D microlithography was used to prepare cell manipulator structures with task-specific shapes. The use of low Youngs modulus photopolymer and carefully chosen polymerization parameters enabled the cell manipulators to be deformed by optical tweezers. The cells were attached to the manipulators merely due to the elasticity of the structures, avoiding biochemical functionalization and enabling the release of the cells at any time. Three types of structures were designed, and three distinct tasks were performed to demonstrate the capabilities of the elastic microtools. Holographic optical tweezers were used to operate the structures. Efficient cell collecting was demonstrated in a microfluidic environment to a pre-defined location. Resolution improvement of 3D imaging of single cell was shown using a cell tweezer structure that holds cells with fluctuations less than 50 nm. Lastly, spatially and temporally controlled cell-cell interaction was demonstrated using a pair of microstructures.