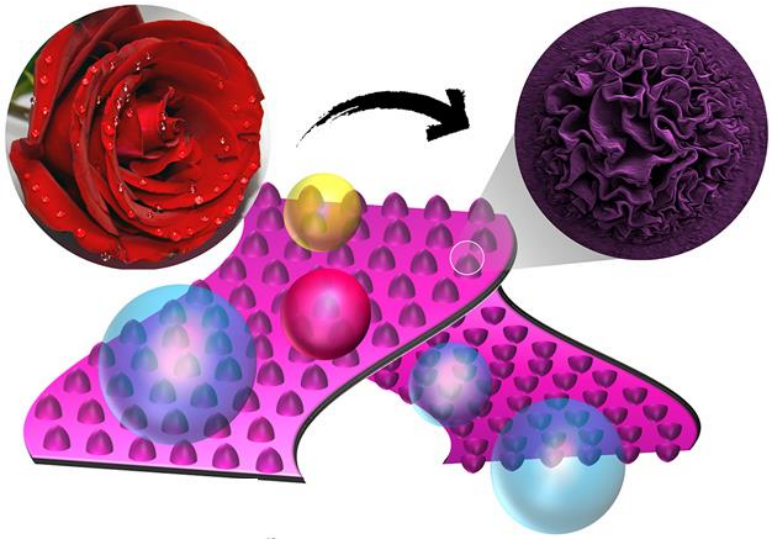
INTERNATIONAL SOCIETY OF
BIONIC ENGINEERING

Rose-Petal-Inspired Hierarchical Papillae for Microdroplet Manipulation



The case was provided by the Individual Member of ISBE

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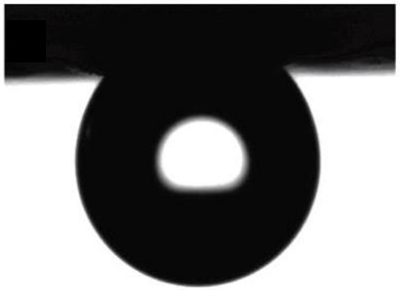
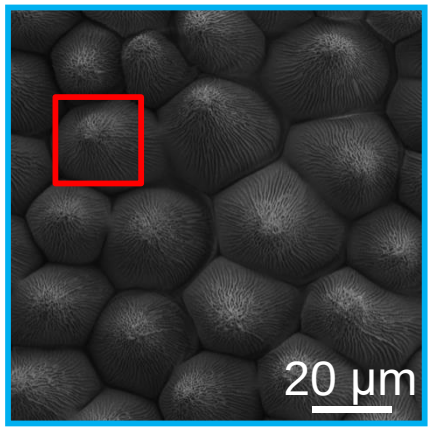
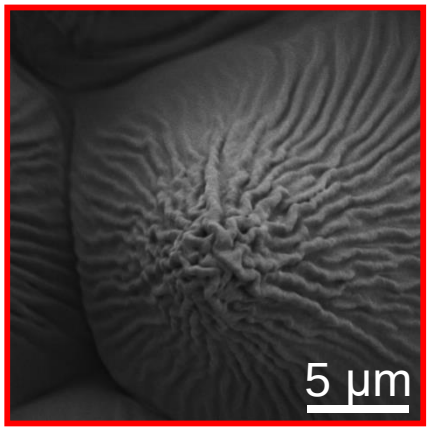
1. Biological Prototype and Bionic Study

Rose petal has evolved to possess hierarchical micropapillae with nanofolds, enabling the petal both superhydrophobicity and high adhesion to water.

Nanofolds provide sufficient roughness to support super-hydrophobicity. Microgrooves allow water to penetrate into partially, leading to high adhesive force with water.



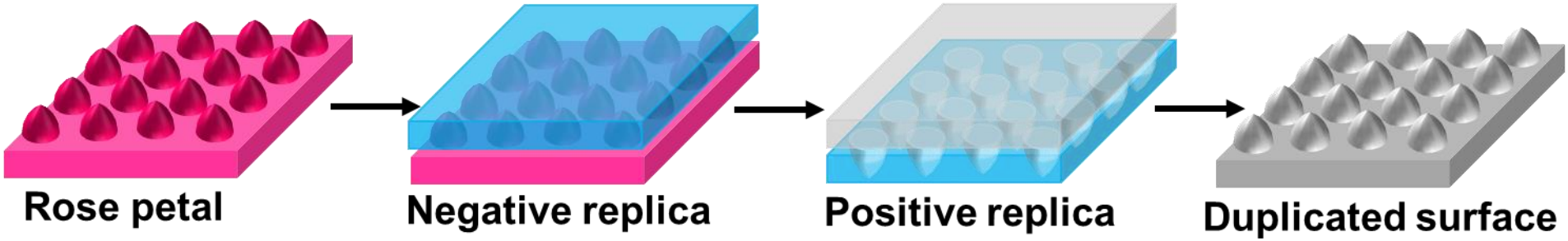




Langmuir 2008, 24, 4114-4119

2. Design and Processing

Many efforts have been devoted to the fabrication of surface microstructures of rose petal. One of the typical methods is using natural rose petal as the template to duplicate the micropapillae on planar substrate.

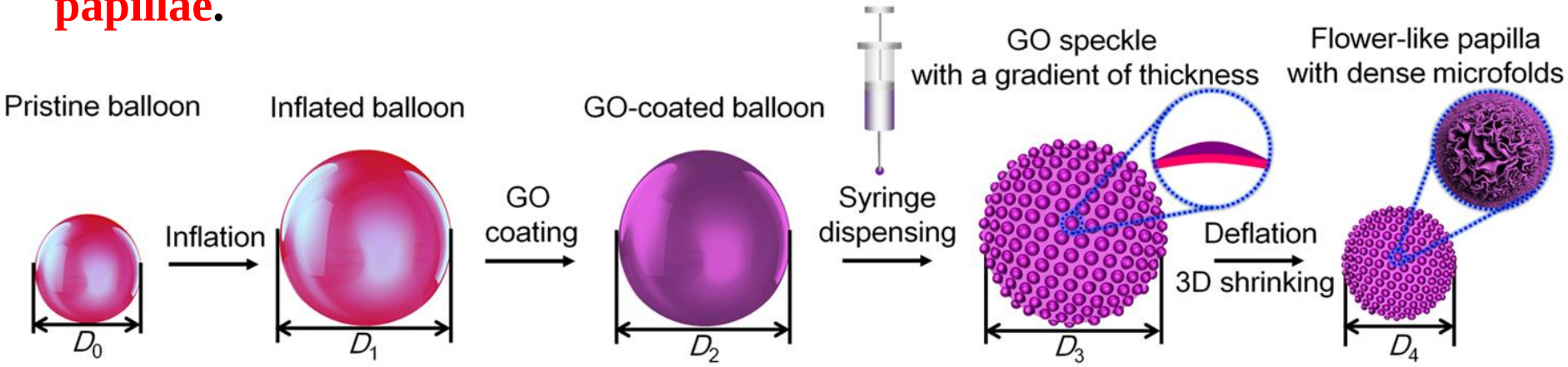


However, template-free, large-area fabrication of 3D hierarchical papillae on curved substrate has not yet been demonstrated, since it is difficult via traditional techniques.

2. Design and Processing

■ Template-free approach for 3D hierarchical papillae

Mother Nature is able to create precise and fascinating morphologies on biological surfaces, such as corrugated membrane of the cell, sulci and gyri of brain cortex, and hierarchical papillae of rose petal. Inspired by these buckling patterns underpinned by mechanics-driven processes, we developed a template-free method for the fabrication of 3D hierarchical papillae.



By dispensing graphene oxide (GO) speckles on an inflated balloon, the speckles spontaneously buckle into hierarchical papillae under tangential compressive stress induced by deflation.

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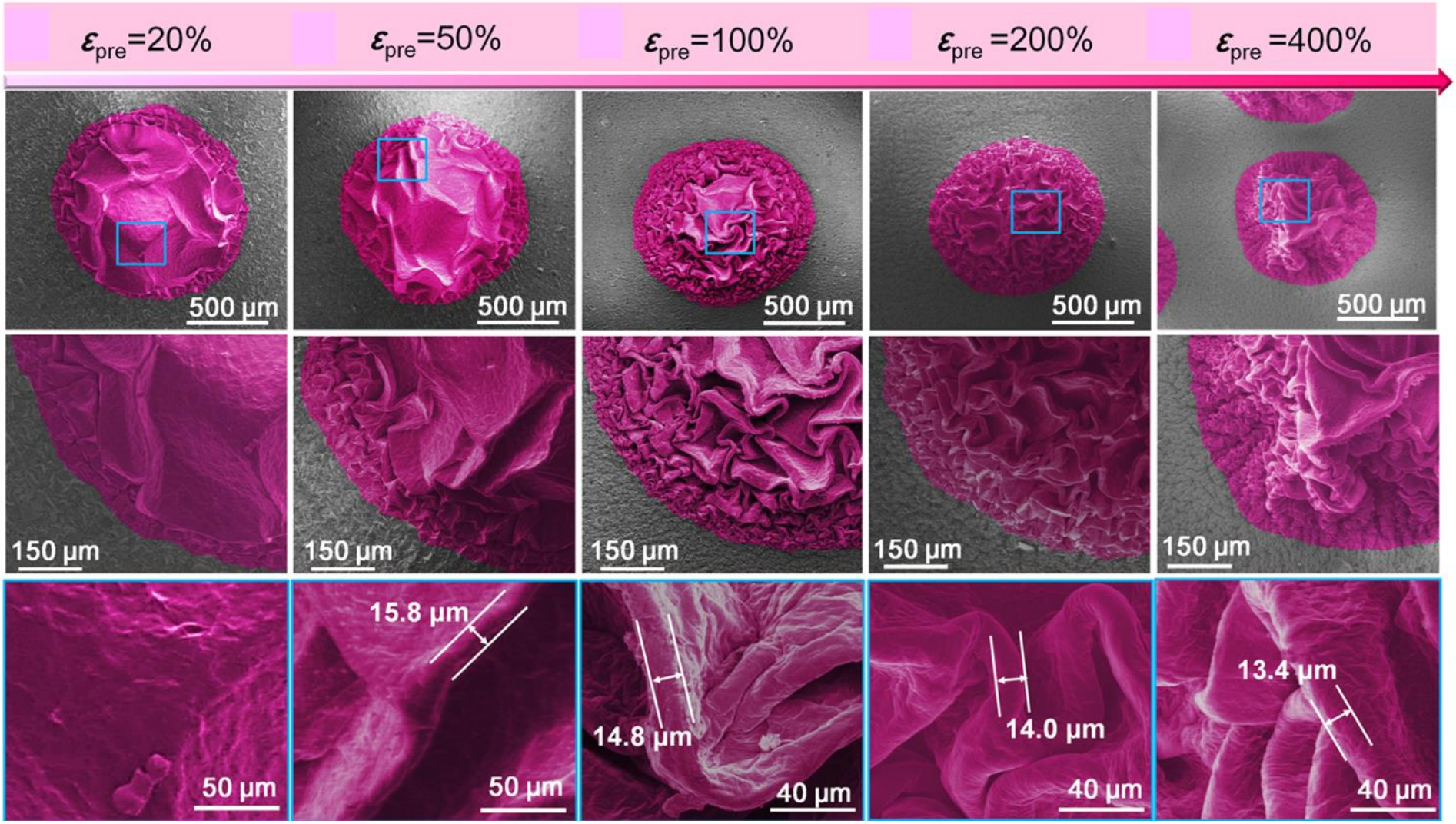
2. Design and Processing

- **Tunable microstructures of the papillae**



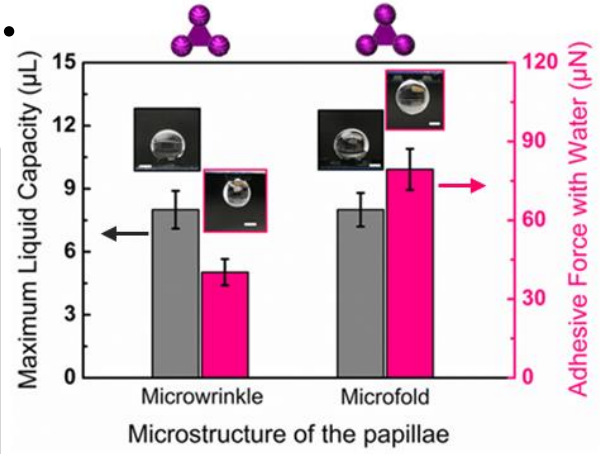
SEM images of buckling papillae (colored with purple) under various prestrains

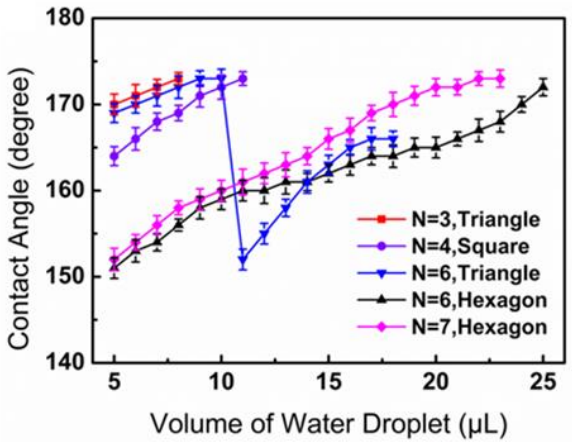
2. Design and Processing

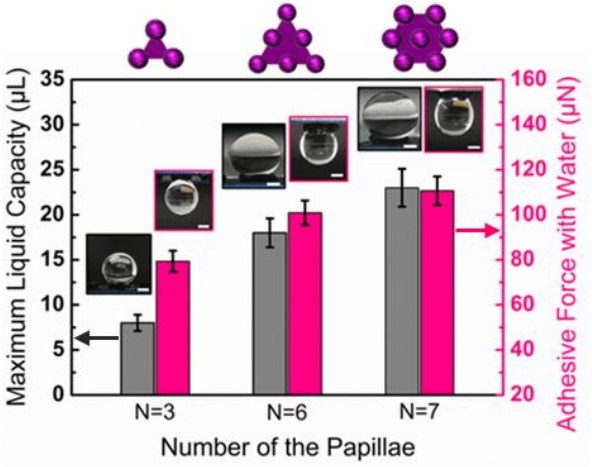
■ Controllable adhesion and liquid capacity of the papillae

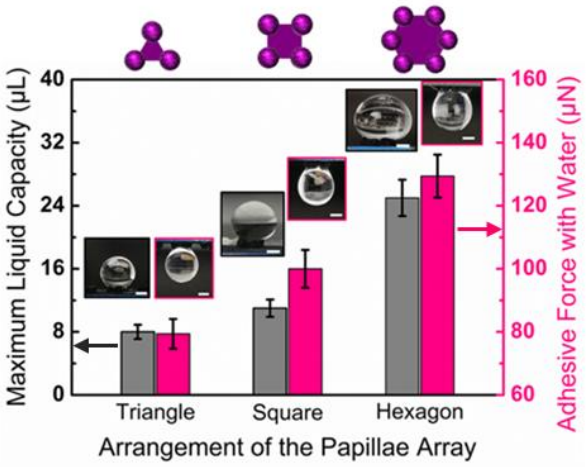
The adhesive force and liquid capacity can be tuned by varying the microstructure of papillae, the number and the arrangement of the papillae arrays.

The papillae arrays exhibit tunable adhesion from 39.2 to 129.4 μN, a maximum liquid capacity of 25 μL and ultrahigh contact angles more than 170°.







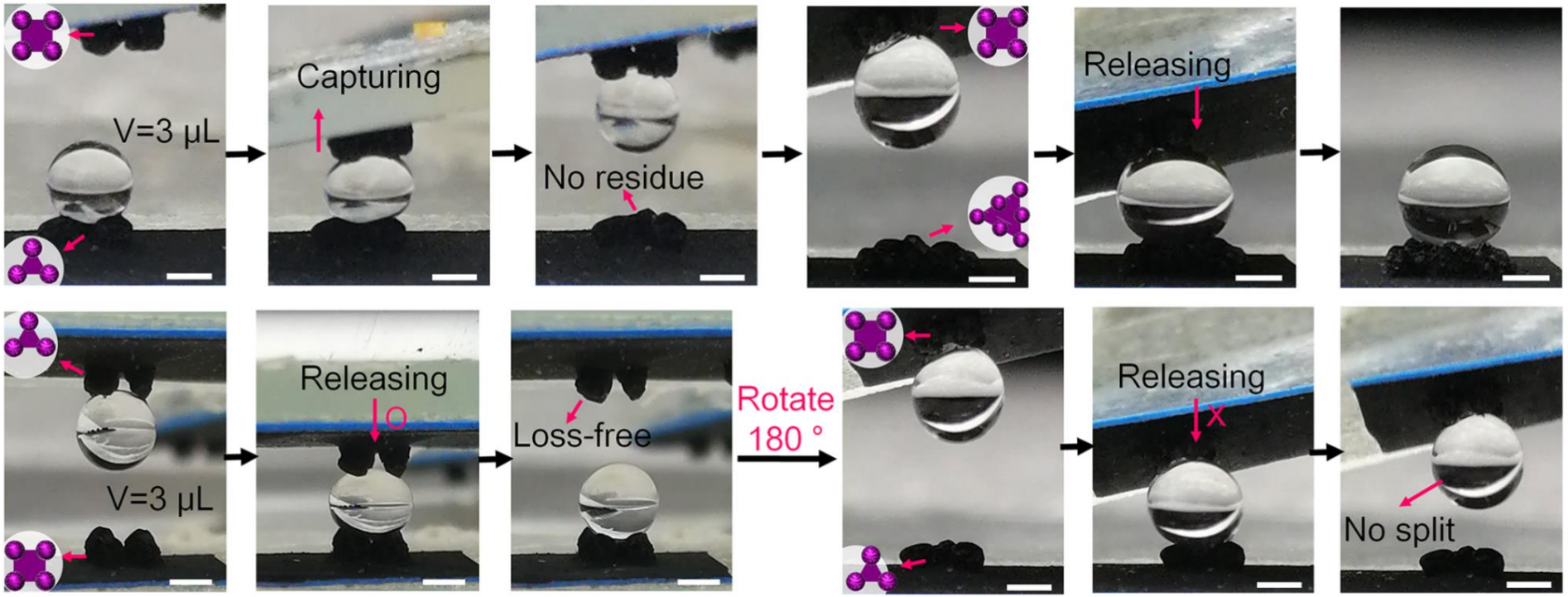


3. Achievements and Application

■ Programmable transfer of microdroplets

To capture a droplet from a substrate and then transfer it to another one in a programmable manner is challenging.

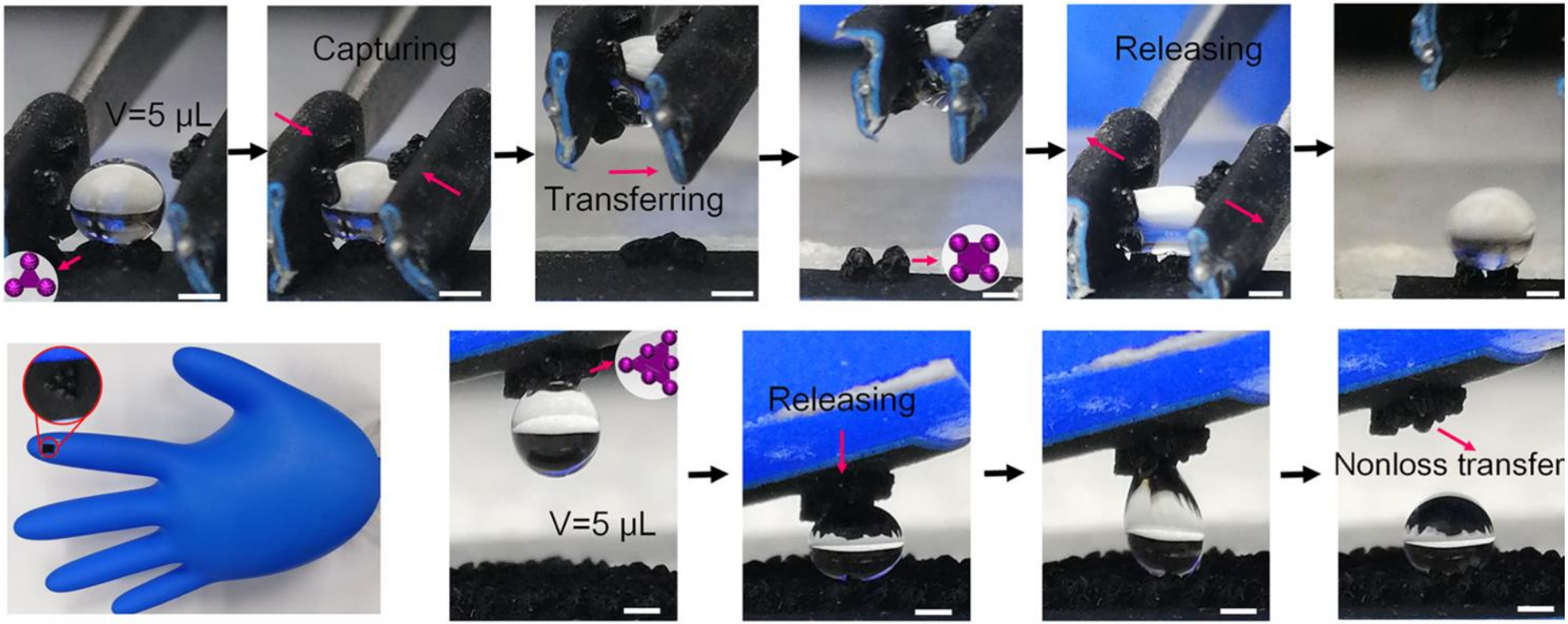
Due to controllable adhesion and tunable liquid capacity, the papillae arrays are such suitable for programmable transferring droplets.



3. Achievements and Application

■ Flexible microdroplet manipulators

Based on flexible latex substrate, the papillae arrays can be assembled to a hard or soft surface such as tweezers or gloves, which can be used as soft microdroplet manipulators.



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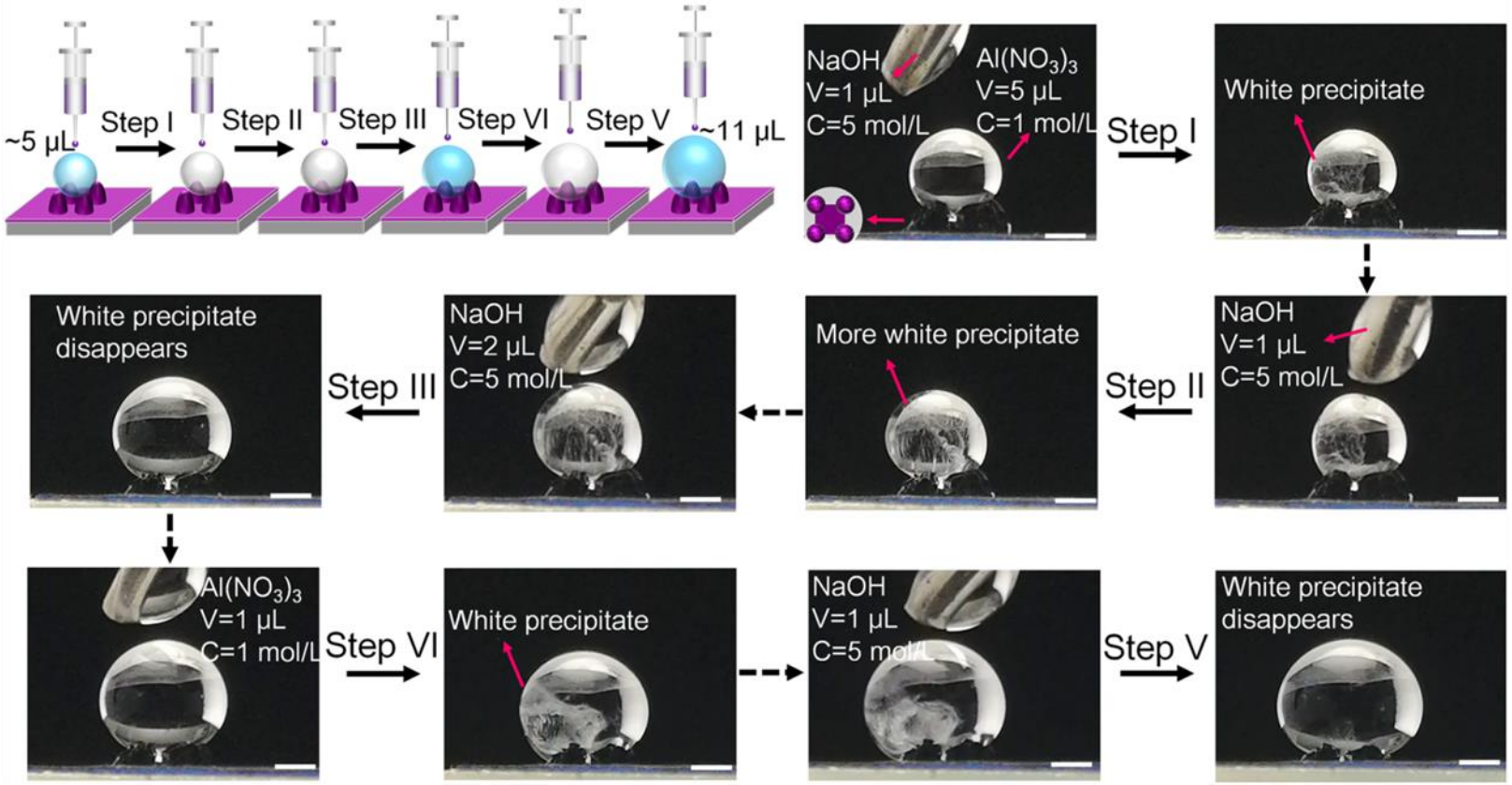
3. Achievements and Application

■ Multistep microreaction platform

Microreactor has significant superiorities in reducing reaction cost and ensuring the safety of experimenters, which allows researchers to observe the real-time reaction-induced phenomena in a transparent droplet.



Demonstration: the multistep precipitation reaction of $Al(NO_3)_3$ and NaOH