Fabrication of PDMS with 3D Microstructure for Antibacterial Antifouling Applications

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1. Introduction

Polydimethylsiloxane (PDMS) with various 2D microstructures is used for microfluidic device and antibacterial antifouling for medical applications to prevent bacterial infection [1-2]. However, moderate surface energy (γ_s: 12.3 mJ/m^2) with soft and flexible properties of PDMS (σ: 5.0 MPa, ε: 116% @RT) limits the increasing of pattern density, hydrophobicity and mechanical strength in practical utilization due to the pattern collapsed [3].

In this paper, the effects of 3D micropillars with two different height on the hydrophobicity, durability and antibacterial properties of PDMS pattern formed by soft lithography process were investigated.

2. Experimental Procedure

First, the silicon (Si) mold of 20 μm square pillars arranged in square (3D Sq.) and hexagonal (3D Hex.) arrays with different heights (h_1: 46.8 μm, h_2: 82.8 μm, h_2/h_1: 1.77) were fabricated by litho-etch-litho-etch (LELE) double patterning process. The PDMS (Sylgard 184, Curing agent: 10 wt%) was poured onto the Si mold. After curing at 75°C/120 min, PDMS was detached from the Si mold. The PDMS with conventional 2D micropillars (h_1: 78.8 μm) and flat PDMS surface were fabricated as control samples. The water contact angle (WCA) was measured by dropped 5.0 μL of deionized water onto PDMS surfaces. The surface stability was analyzed by using water contact angle hysteresis (CAH).

The bacteria adhesion assay of sterilized PDMS samples with ultraviolet light were investigated by using *Escherichia coli* (*E. coli*, ATCC 8739). The PDMS samples were immersed in Nutrient broth with inoculated *E.coli* (~10^5 CFU/mL) at 37°C for 7 days. In order to eliminate unattached bacteria, the PDMS samples were rinsed with phosphate buffer saline (PBS) and dyed with Gram's stain. The amount of *E. coli* on PDMS samples were investigated by optical microscope (OM).

3. Results and Discussion

Figure 1 showed that the WCA of PDMS with 2D Sq., 3D Sq., and 3D Hex. array micropatterns were 139.2±4.0°, 150.1±2.9°, and 150.3±4.2°, respectively. The water CAH of PDMS with 2D Sq., 3D Sq., and 3D Hex. array micropatterns were 6.2°, 2.9°, and 1.2°, respectively. The surface of PDMS with 3D Hex. array pillars showed higher superhydrophobicity and more stability compared to the surfaces with 2D Sq. and 3D Sq. array pillars. Figure 2 showed that the attachment of *E. coli* on PDMS samples with 3D Hex. array pillars is significantly reduced compared to other micropillar structures. This is attributed to the increasing roughness and pattern displacement by the high surface topology of adjacent pillars with two

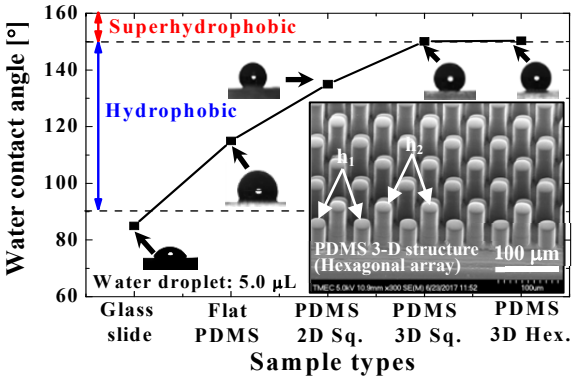

Fig. 1. WCA and water droplet on PDMS surfaces with different microstructures. Inset picture is SEM image of PDMS with 3D micropillars arranged in hexagonal arrays.

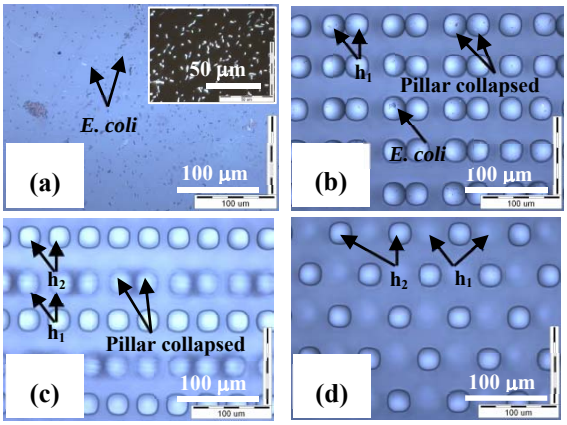

Fig. 2. Top view OM images of *E. Coli* adhesion on different PDMS surfaces. (a) Flat surface, (b) 2D Sq. array pillars, (c) 3D Sq. array pillars and (d) 3D Hex. array pillars.

different heights arranged in hexagonal array [3]. This, in turn, led to excellent superhydrophobic and antibacterial properties without pattern collapsed.

4. Conclusions

The effects of PDMS with 3D microstructure with two different heights on the antibacterial properties were investigated. The PDMS with 3D micropillars arranged in hexagonal array increased surface roughness and suppressed pattern collapse, which led to excellent antibacterial antifouling properties.

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