Cell Traction Force Measured using Microposts with Nanopillars

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Surface conditions including topography and surface coating can influence cell traction force and regulate cell migration. Micropost sensors with parallel guiding gratings had been fabricated in polydimethylsiloxane (PDMS) to measure the cell traction force during topographical guidance. However, very little is known about how the dynamic traction force is related to cell migration behaviors on surfaces with different morphologies and coatings. To monitor cell traction force under various surface conditions, microposts with nanopillars and various coatings were developed.

SU-8 nanopillars were fabricated by nanoimprint lithography, as shown in Fig. 1(a). Microposts were patterned on top of the nanopillars by optical lithography. Subsequently, nanopillars not covered by the photoresist were removed by reactive ion etching (RIE). The photoresist was used as an etch mask to etch the silicon (Si) microposts with a deep RIE system, as shown in Fig. 1(b). After removing the photoresist, the thin residual layer around the SU-8 nanopillars was removed by RIE. Finally, Si nanopillars were etched into the Si, and the SU-8 etch mask was removed using an O_2 plasma, as shown in Fig. 1(c). PDMS was poured onto the Si mold coated with trichloro(1*H*,1*H*,2*H*,2*H*-perfluorooctyl)silane (FOTS) and degassed in a vacuum chamber for 2 h, as shown in Fig. 1(d). A PDMS negative mold was generated after curing at 20 ℃ for 12 h and baking at 110 ℃ for 15 min. After coating FOTS on the negative mold, it was imprinted in PDMS, as shown in Fig. 1(e). Microposts with nanopillars were obtained after curing at 20 ℃ for 12 h and baking at 110 ℃ for 6 h, as shown in Fig. 1(f).

Figure 2 shows micrographs of microposts array without and with nanopillars. The platforms were coated with fibronectin on top and immersed in a lipophilic dye, followed by immersion in a Pluronic solution. MC3T3-E1 cells with a density of 2×10^4 cells/cm^2 were seeded. For accuracy analysis of the micropost position, time-lapse images in bright field and fluorescent images of the stained plaform were captured. In Fig. 3(a), a cell seeded on the top of the microposts caused the posts to bend due to cell traction force. Cells on microposts with nanopillars had more filopodia and longer protrusions, which affected the cell migration behaviors and resulted in larger traction force. Figure 3(b) shows that the normalized traction forces of the leading, middle, and trailing regions for cells seeded on microposts with nanopillars were larger than those on microposts without nanopillars.

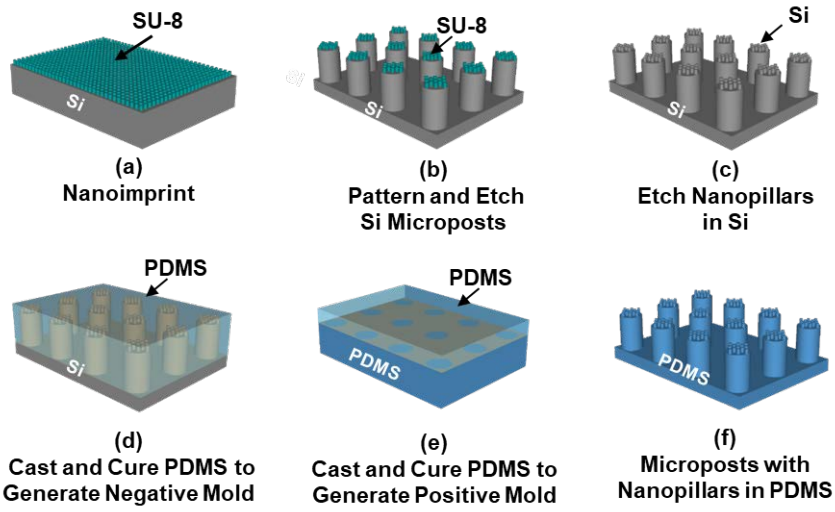

Figure 1: Schematics of fabrication technology for microposts with nanopillars.

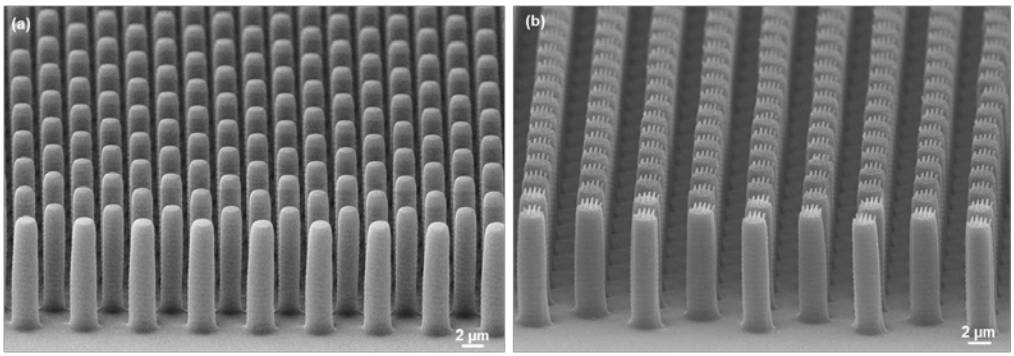

Figure 2: Micrographs of (a) microposts without nanopillars and (b) microposts with nanopillars.

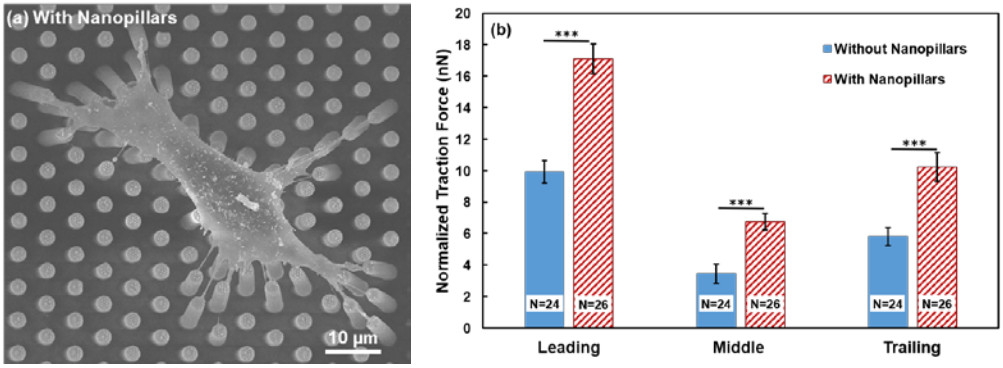

Figure 3: (a) MC3T3-E1 cell on microposts with nanopillars. (b) Normalized traction force in leading, middle, and trailing regions of cells on microposts without and with nanopillars. One way ANOVA with Tukey's post-hoc test with ***p <0.001.