Cell Migration Direction Switched by Angular Gratings

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Cell migration, which is essential in a variety of human activities, has been demonstrated to be influenced by the relief topography on substrates. However, the control of the migration directions is rarely reported. In this study, we examined directional changes of MC3T3 osteoblast cells on angular gratings fabricated on PDMS substrates. Directional change dependence on bending angles and segment lengths were presented.

Figures 1(a-c) depict the morphology of the cells at different bending corners. On angular gratings with 45° and 90° bending corners, groups of filopodia protrude around the corner edges, shaping the cell bodies to be triangular. Especially for the 45° bending corners, 27% of the cells were observed to travel along the bending tips while none of cells followed the bending tips on 90° bending corners. On 135° angular gratings, the two sides of the filopodia are attached to the two sides of the corners similar to the elongation on straight gratings. The results suggest that more robust focal adhesions are formed at sharper topographical edges. Figure 1(d) shows the reversal (probability of making a reversal) and persistence (probability of passing the corner) rates when a cell encounters a bending corner. The two rates do not add up to be 100% for the 45° angular gratings since 27% of the cells are directed along the tips. The persistence rate increases as the bending angle becomes larger.

Figure 2 shows cell persistence rate at the 45° and 135° bending corners. The x-axis represents the length of the segment where the cells are migrating from. Cell behavior on 50 μm long segments of asymmetrical angular grating pattern is different from the designs with 100 μm and ≥200 μm long segments. The persistence rate for cells on 135° asymmetrical angular grating pattern is 90%, much higher than the 26% persistence rate for cells on 45° asymmetrical angular grating pattern. Such design with short grating segments and 135° bending corners can provide good directional control for cells to move forward. On the other hand, 45° asymmetrical angular grating pattern with 50 μm long grating segments has low cell persistence rate around the bending corners and such design can be used to switch the cell migration path to a different direction.

In summary, we presented how the directional reversals can be provoked by the patterned topography from the engineering point of view. The knowledge developed in this study on how cell migration direction is switched can be applied in cell migration platform design.

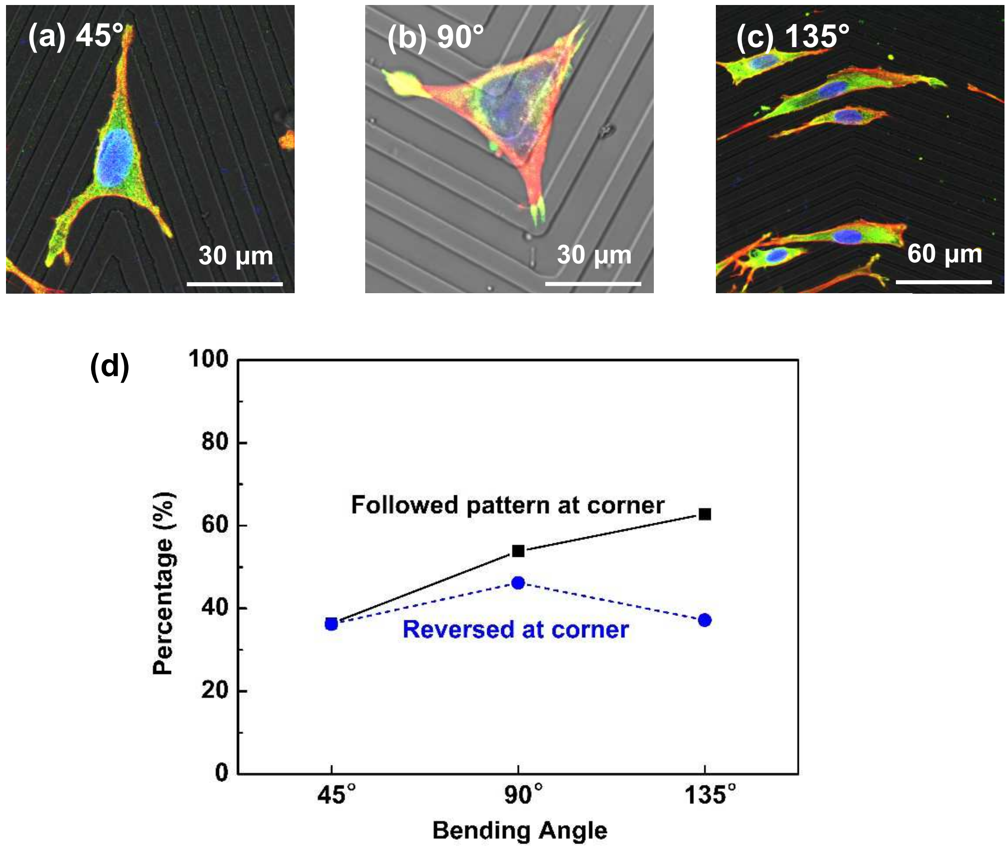

Figure 1: Immunofluorescence of MC3T3 cells on symmetrical angular gratings with (a) 45°, (b) 90°, and (c) 135° bending. (d) Percentage of cells that followed gratings or reversed direction at different bending corners.

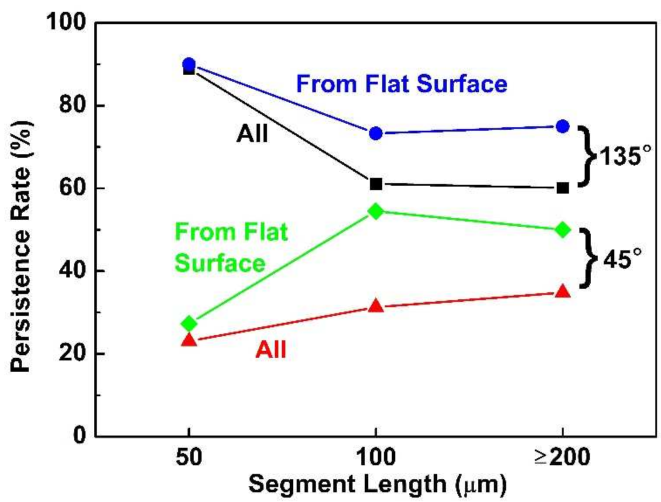

Figure 2: Persistence rate at corners of cells migrating from grating segments with different lengths and bending angles of 45° and 135°.