A two-step hot embossing process for fabrication of nano/micro hybrid lens

Jing-Tang Wu, Wei-Yi Chang, and Sen-Yeu Yang*
Department of Mechanical Engineering, National Taiwan University, Taipei 106, Taiwan
*E-mail: syyang@ntu.edu.tw

In this paper, we present a novel and low cost fabrication of nano/micro hybrid lens array using hot embossing with anodic aluminum oxide (AAO) template. The nanostructures and microlens array are fabricated on the same PC substrate by hot embossing in two steps. The first step is the fabrication of nanostructures on the PC film using hot embossing with an AAO template as shown in figure 1(a). The AAO templates with periodic porous nanostructures are fabricated using a two-step anodization process. When aluminum of high purity is anodized in an acidic electrolyte, a porous alumina membrane with highly uniform and parallel pores and straight walls is formed. Its structure is formed as closed-packed hexagonal array of columnar cells, each containing a single pore of which the side and interval could be controlled by adjusting the forming conditions.

The second step is the fabrication of convex microlens on the nanostructured film. The mold of the micro-holes array is formed on a stainless-steel sheet of 50μm thickness using photolithography and wet etching processes. As shown in figure 1(b), during the hot embossing process, an array of convex microlenses is formed by partial protrusion of the soften film into the micro-holes of the mold under the effects of the capillary force and surface tension. Using this fabrication process, nanostructures can be successfully fabricated on the polymeric convex microlens.

Figure 2 shows the SEM images of the fabricated microlens with nanostructures on the PC film. The polymeric microlens was fabricated by using the capillary forming method as shown in figure 2(a). It was fabricated under the embossing parameter of 140℃ and 15 kgf/cm^2. As shown in figure 2(b), the average sag height of the fabricated microlenses is 10.8 μm, which was measured by a surface profiler (Tylor/Hobson). As shown in figure 2(e), nanostructures were fabricated on the PC film using hot embossing with AAO template. They were fabricated under the embossing parameter of 150℃ temperature and 20 kgf/cm^2 pressure. The heights were about 260 nm.

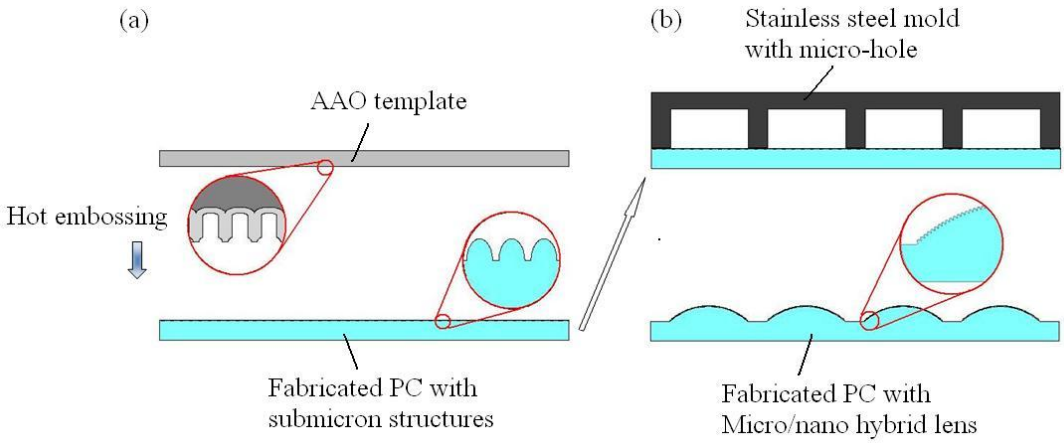

Figure 1. Schematic showing the process of nano/micro hybrid lens on the PC film using gas-assisted hot embossing

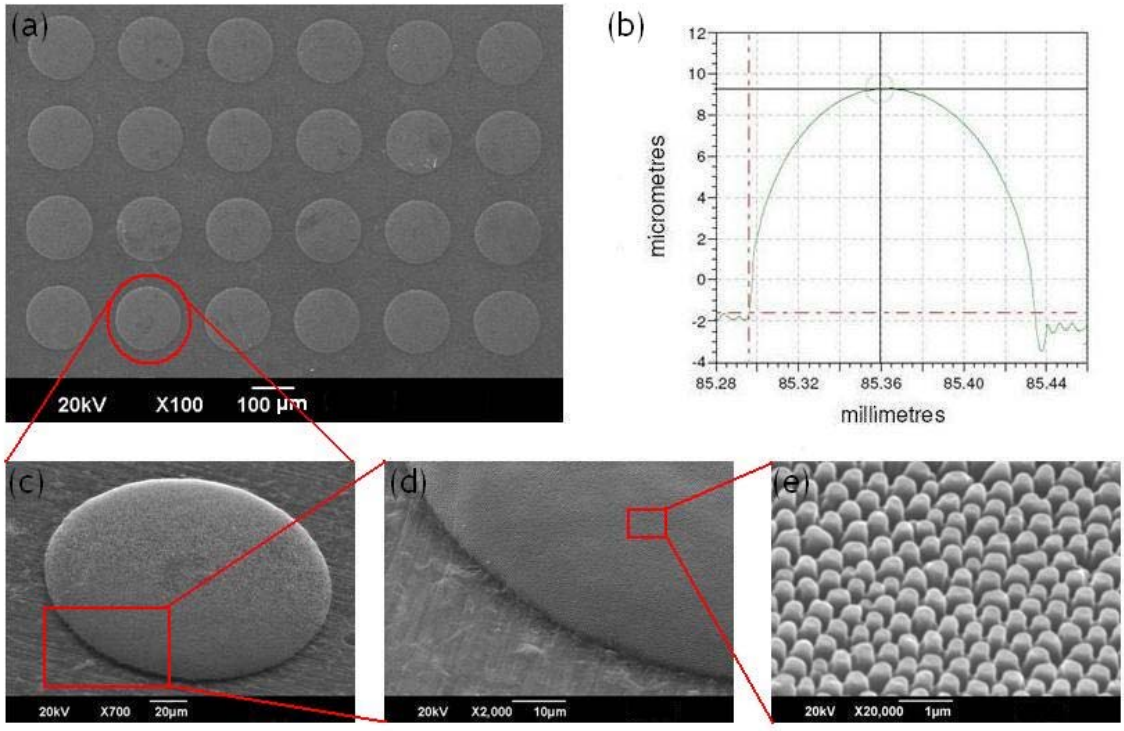

Figure 2. SEM images of the fabricated PC film with nano/micro hybrid lens array