ROLL-TO-ROLL NANOIMPRINT LITHOGRAPHY OF POLYETHERSULFONE ULTRAFILTRATION MEMBRANES AND FOULING MITIGATION EFFECTS

Jacob Hutfles, University of Colorado Boulder
Xiao Yun Lu, University of Colorado Boulder
John Pellegrino, University of Colorado Boulder

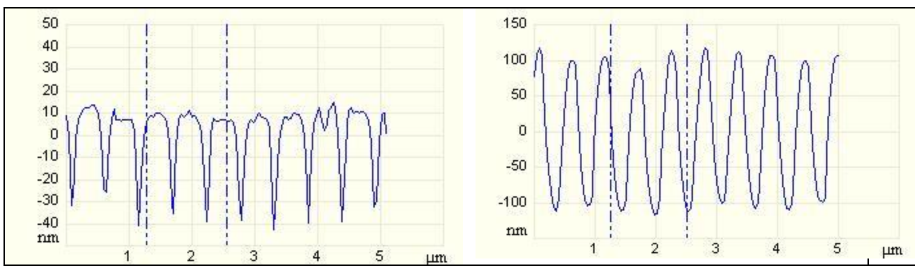
Key Words: ultrafiltration membrane, fouling mitigation, nanoimprint lithography

Previous research has shown that embossing commercial polyethersulfone ultrafiltration membranes with sub-micron surface patterns increases the critical flux and reduces the rate of cake layer formation when filtering model solutions. These membranes were created using traditional nanoimprint lithography (NIL), by which a lithographically defined silicon wafer is pressed against a membrane at elevated temperatures and pressures. In order for this technological advance to be translated into commercial application, the embossing must be done using a high-throughput manufacturing method.

The focus of ongoing research has been to move the imprinting process into a roll-to-roll process. In this process, the membrane and mold are fed through a pair of rollers, and at the center nip of the rollers, the membrane is pressed into the periodic grooves of the mold. There are two ways of controlling the pressure applied by the rollers. The first is to set a distance between the rollers (roll gap), such that a percent reduction in thickness of the membrane defines pressure. The second is to have a moving roll gap where a constant force is applied to the rollers, thus a constant pressure to membrane. We have found that both methods successfully transfer patterns to the membrane. Preliminary results have shown that pattern transfer can be obtained at room temperatures, with permeance (though somewhat reduced) being retained by the membrane.

An important aspect of the research has been the selection of the mold used in the imprinting process. Currently, a commercially available nickel (Ni) pattern has been used. This was chosen because of its flexibility and mechanical toughness. Another important aspect is the type of pattern on the mold. Previous research was done with a line-and-groove pattern ("square"), but the Ni one has a sinusoidal pattern. We have currently been investigating the induced hydrodynamic effects of the sinusoidal versus square patterns. For a membrane, directly imprinted using the Ni mold, results indicate there is still a reduced rate of fouling similar to prior results using the square one.

Using a Ni mold to imprint the membrane is still cost prohibitive. Thus, a low cost, high strength, and highly durable mold must be created. As part of ongoing research, we have imprinted a high T_g polymer with the Ni mold. This flexible film has been successfully used as the mold for membrane imprinting (see Figure 1). The goal of imprinting the flexible film is to create a large patterning mold and thus larger patterned membrane areas can be used in application testing, thus, yielding greater confidence in their value-in-use.



igure 1 – AFM profile of nprinted high T_g film (left) nd membrane imprinted h the high T_g mold (right)

Lastly, our research will focus on filtering complex solutions with patterned membranes. Thus far, separations were evaluated using model solutions, but we are also investigating fouling improvements for patterned membranes filtering milk suspensions.