Roll Diameter Amplification Method using Direct Transfer of Fine Patterned Small Roll Mold Fabricated by Electron Beam Lithography

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The roll-to-roll (RTR) technique is a high-throughput production method for nanoimprint lithography (NIL) [1, 2] however, the fabrication of the roll mold for RTR NIL is difficult because of the cylindrical shape of the mold. Roll molds are usually fabricated by rolling up a nickel-plated foil with a nanopattern or by lathe turning with a tool with a small cutting edge. However, the former method generates a seam, and there solution of the latter is limited by the size of the tool's cutting edge. To obtain a seamless nanoscale mold, we have developed a technique for direct writing with an electron beam (EB) on a rotating cylindrical substrate. The method uses a cylindrical substrate (the roll mold substrate) coated with a resist that is direct written on by an EB as the roll mold substrate is rotated in a vacuum[3]. However, throughput of EB direct writing is very slow. To improve low throughput, we investigate roll diameter amplification method using direct transfer of patterned small mold.

Figure 1 shows the concept of roll diameter amplification method and transfer result. The roll mold was made of quartz and diameter was 32 mm. This roll mold was dipped in hydrogen silsesquioxane (HSQ) which acts as high resolution negative type EB resist. After the coating EB resist, EBL was carried out with 30 kV acceleration voltage and 100 nA EB current. After the development, 520 nm line patterns were obtained on quartz roll mold (see Fig.1). Using this transparent roll mold, direct transfer to large mold was carried out with the 0.2 rpm rotating speed, 60 N nip forces, 60 mW/cm^2 UV dose. A diameter of large mold was 150 mm and this mold was lapped with UV-curable film (HB038, Bridgestone Co., LTD.). The transfer lines widths were 510 nm (see Fig.1). Using patterned polymer large mold, RTR UV-NIL was carried out with 1mm/sec feed speed, 0.25MPa nip pressure and 87 mW/cm^2 UV dose. Transfer film was UV-curable film (HB038, Bridgestone Co., LTD.). Figure 2 shows the schematic diagram of RTR UV-NIL process and transfer result. The replicated lines widths were 590 nm and this value is almost the same as mold width. Therefore, the roll diameter amplification method is very effective for RTR NIL because small diameter roll master mold can be used.

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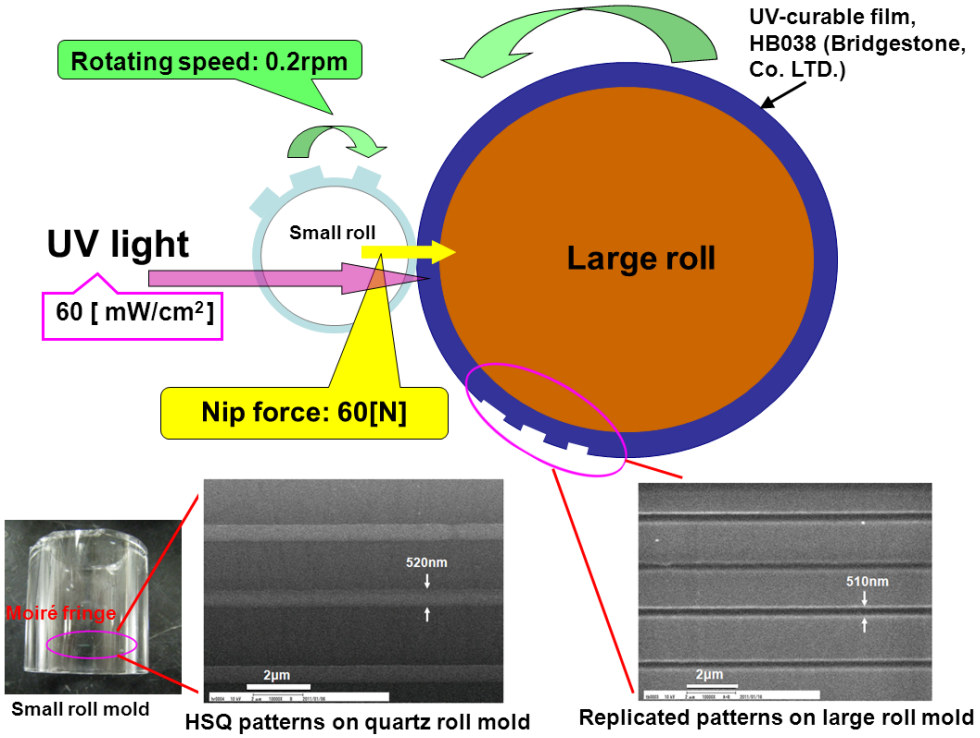

Figure 1: The concept of roll diameter amplification method and transfer result.

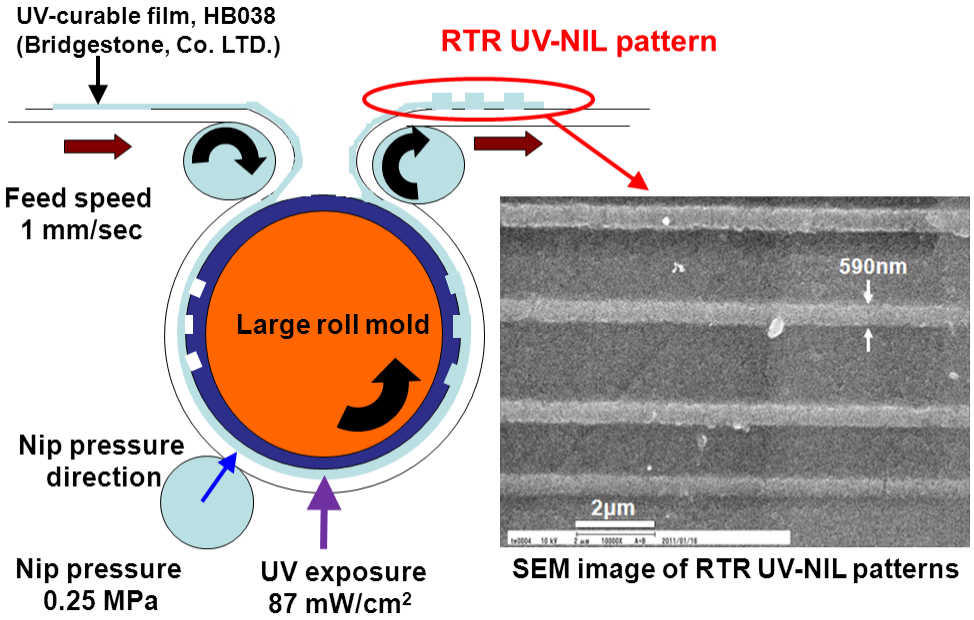

Figure 2: The RTR NIL using UV-curable film and transfer result.