# Fast and Continuous Patterning on the Surface of Plastic Fiber by Using Thermal Roller Imprint

A. Ohtomo, M. Kokubo, H. Goto
*Bio-Electromechanical-Autonomous-Nano-Systems (BEANS) Project,*
*Toshiba Machine Co., Ltd., 2068-3 Ooka, Numazu, Shizuoka, Japan 410-8510*
*aohtomo@beanspj.org*

H. Mekaru, H. Takagi
*Bio-Electromechanical-Autonomous-Nano-Systems (BEANS) Project,*
*National Institute of Advanced Industrial Science and Technology (AIST), 1-2-1 Namiki, Tsukuba, Ibaraki, Japan 305-8564*

We succeeded in high-speed continuous patterning on the surface of plastic fiber at a feeding speed 20 m/min by using thermal roller imprint method. We used a cylindrical mold with seamless micro-structures ingrained on its surface. Figure 1 shows a schematic of the developed thermal roller imprint system where a plastic fiber is pressed between a cylindrical mold and a backup-roller. Any movement of the cylindrical mold in the direction of space-change between the mold and the backup-roller can be precisely controlled. A press force during imprint can be measured by a load cell located beneath the backup-roller. The cylindrical mold and backup-roller while heated up to 250°C, can be rotated synchronously with the motion of the plastic fiber, making continuous patterning of micro-structures possible. Since in feed back during high-speed imprinting the press force cannot be adequately controlled, we devised a scheme where the system memorizes the relative press positions corresponding to the phase angles of the cylindrical mold at low sending speed under controlled press force. Here, the periodic variation of the center-to-center distance between the cylindrical mold and backup-roller can be measured at set intervals. By using the memorized relative positions, the position of the cylindrical mold is then moved. Figure 2 shows the time variation of press force and press position during imprint. When the press position was fixed the standard deviation of press force was 6.86 N. The value dropped to 2.80 N when programmed driving method was employed. Figure 3 shows the depth variation of imprinted pattern at feeding speed 20 m/min. Phase angle corresponds with that of cylindrical mold. The range of depth variation was 7.2 µm when the press position was fixed. This number went down to 3.4 µm when programmed driving method was employed. This thermal roller imprint system was developed for the BEANS project that is developing various flexible e-textiles. Next, we plan to use these concave micro-structures on the fiber as positioning guides for weft and warp in a weaving process.

This work was supported by the New Energy and Industrial Technology Development Organization (NEDO).

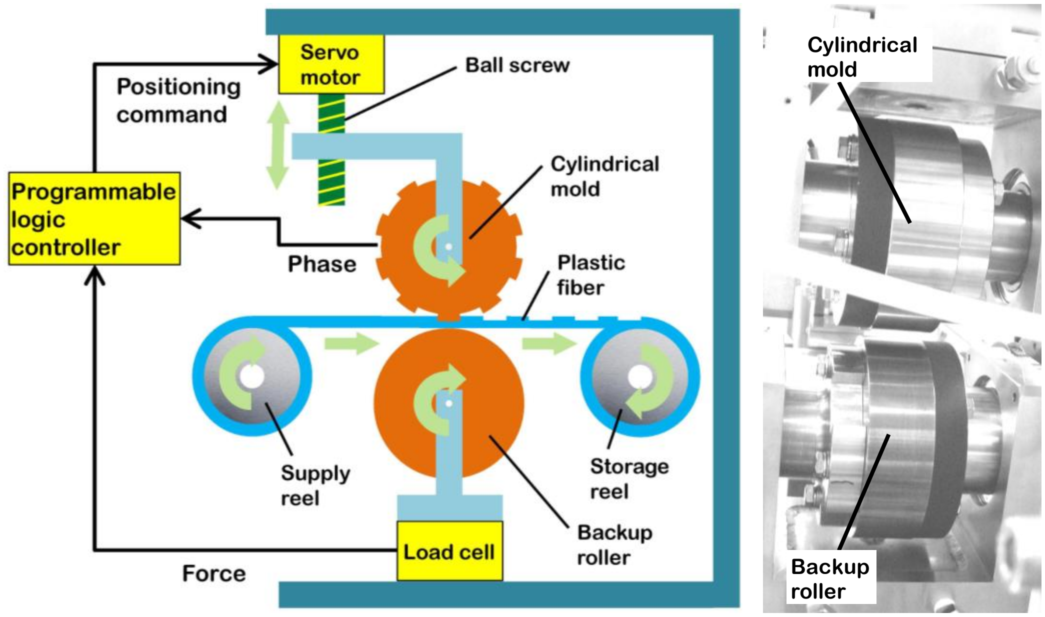
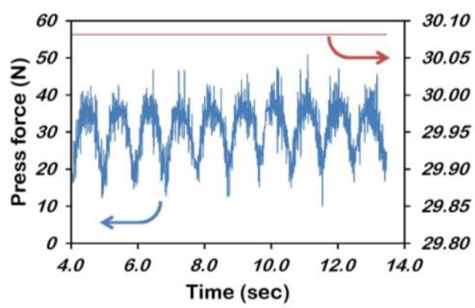
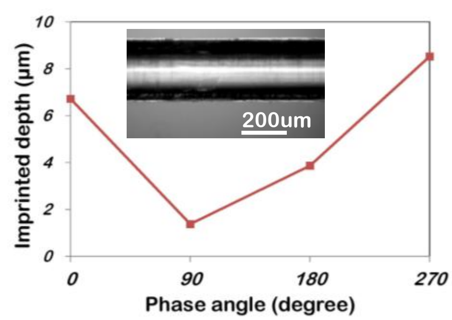


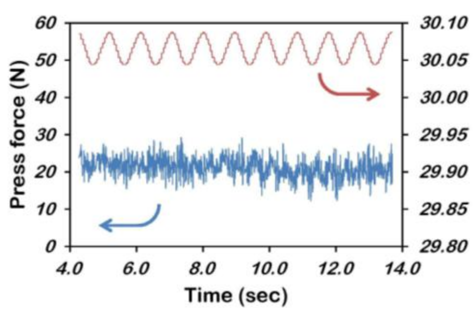

*Figure 1: The schematic of the thermal roller imprint system. Right photograph is a close-up view of the imprint section.*



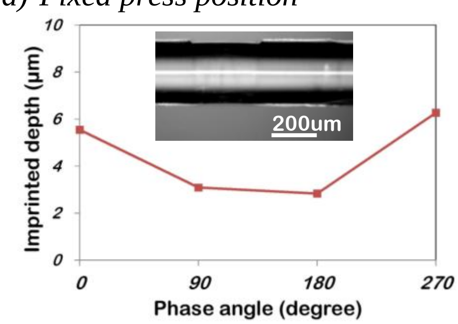

*(a) Fixed press position*




*(a) Fixed press position*




*(b) Programmed driving*




*(b) Programmed driving*

*Figure 2: Time variation of press force and press position at feeding speed 20 m/min: (a) Under fixed press position, (b) under programmed driving ~cyclic variation of press position conforms to the rotation period of the cylindrical mold.*

*Figure 3: Depth variation of imprinted pattern at feeding speed 20/min (corresponding to the circumferential length of the cylindrical mold): (a) Under fixed press position, (b) under programmed driving. The insets are the optical micrographs of the imprinted micro patterns.*