Roll To Roll Nanoimprinting Of Conducting Polyaniline Using A Novel Imprinting Device

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High speed printing tools with submicron resolution have been presented already and used commercially in manufacturing of e.g. optical elements. [1] The resolution is normally limited to few hundreds of nanometers. Nanoimprinting techniques can be used in a roll to roll process when speed, temperature and pressure are precisely controlled. However, one diffuculty is to achieve a submicron resolution in the roll stamp.

When regular thermoplastic polymers are used the imprint times reported usually exceeds tens of seconds. We have demonstrated earlier that the imprinting time can be reduced to a few seconds when the step & stamp imprint method is used. [2] In this work we have investigated roll to roll manufacturing of submicron structures using a custom built laboratory scale imprinting tool (fig. 1). Using the lowest speed in the machine the estimated imprinting time was 3 seconds. Nickel stamps [3] were used as imprinting stamp attached to a printing cylinder. Stamps were heated using electrical heaters installed inside the printing cylinder.

In this roll to roll device a gravure printing unit and the imprinting unit can be used at the same time inline. The gravure unit is used to coat a polymer layer on the substrate followed by the imprinting unit to pattern the polymer. We have demonstrated this option by using inherently conductive Polyaniline-dodecylbenzenesulfonic acid (PANI-DBSA) in toluene/sellosolve as a printing ink. [4] Patterned conductive structures down to 300 nm on polypropylene are achieved when a speed from 0.2 – 1.0 m/minute and 5-14 MPa pressure are used (fig. 2). The temperature was kept constant, 25 C during the process. The layer's conductivity of 3 S/cm does not change in the imprinting process. As a comparison 100 nm width gratings was roll to roll nanoimprinted on 95 µm cellulose acetate film. Speed was varied from 0.2 – 5 m/min, while pressure was kept 8.3 MPa and temperature 105 C. Roll to roll imprinted structures were analyzed using optical microscopy, AFM characterization and in case of PANI-DBSA by conductivity measurements.

References:

[1] M.T. Gale & Al., Optics and Lasers in Engineering 43 (2005) 373 -386
[2] T. Mäkelä & Al. Trends in Nanotechnology (TNT2005). Oviedo, ES, 29 Aug. - 2 Sept. 2005. CD-ROM. PHANTOMS Foundation (2005) and 3rd international Conference on Nanoimprint and Nanoprint Technology, NNT2004. Wien, 1 - 3 Dec. 2004. Poster. AMO GmbH (Gesellschaft für angewandte Mikro- und Optoelektronik) (2004)
[3] P. Majander & Al., 4th International Conference on Nanoimprint and Nanoprint Technology, NNT2005, Nara, 19-21 Oct. 2005. Poster
[4] T. Mäkelä & Al., to be published

Figures:

Fig.1. Novel roll to roll nanoimprinting tool.

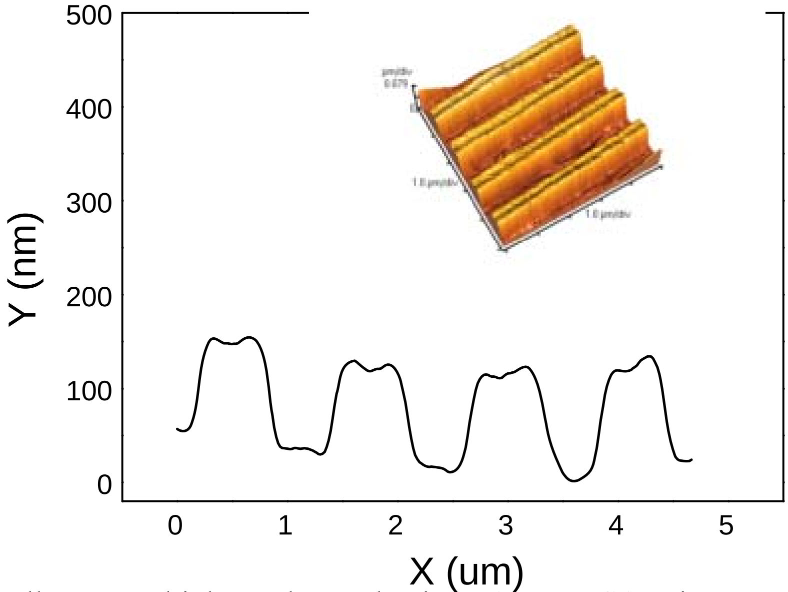

Fig.2. Roll to roll patterned inherently conductive PANI-DBSA using gravure printing unit and the imprinting unit at the same time inline.