NIL processes and material characterization on transparent substrates for optical applications

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NanoImprint Lithography (NIL) is a very promising technique for optical applications and many publications have been already reported on these topics. Industrial applications require a high control of the process and materials. This implies a good understanding of the physico-chemical behaviour of the polymers used and of the imprint mechanisms. NIL technology has reached a high maturity level on Silicon wafers, but optical applications require mostly transparent substrates, such glass or soft polymers. The imprinted materials have also specific requirements: their properties have to be studied carefully and linked to their imprint behaviour in relation with the corresponding substrates.

The Silicon molds are imprinted using an EVG®520HE equipment into glass plates covered with different polymers or into a Polycarbonate (PC) sheet. One example of the imprint results is presented on figure 1 with a photograph of a totally embossed 200mm PC plate. The different gratings correspond to various dot sizes and periods, which induce different colours in diffracted light. SEM pictures of the patterns imprinted in one grating are shown on figure 2. The dot width and period are 400 nm and 1 µm respectively, and their height is 600 nm. Other imprint results will be presented on glass substrates using several polymers.

One important issue of the imprint on glass is the adhesion of polymer on the glass substrate. It will be shown how material properties influence these criteria, and therefore the structure stability. These results are based on the surface energy characterization and a measurement of the adhesion force. We will present a comparison of several permanent polymers and study the filling mechanisms depending on the imprint process: thermal embossing or UV-NIL. Optical applications require polymers which have a high stability. Particularly they don't have to be damaged by high temperatures or UV exposure. Some ageing tests will be presented to compare the materials.

The basic idea of OLED is to control light propagation by means of ordered structured substrates of alumina. The highly ordered regular structures allow controlling the light with the possibility to realize high extraction efficiency and antireflective structures as shown in the optical simulations proposed in figure 3. The proof-of-concept reported here regards the integration of NIL structured plastic substrates in OLED device in order to improve the extraction of light. In figure 4a an example of OLED device with both surfaces patterned is shown under applied voltage of 6V. In figure 4b the emission at 0° (normal to the emission surface) investigated by coupling of a spectroradiometer and optical microscope shows the increasing of the external efficiency respect to a flat surface is the range of 35-40% with one side pattern and more than 50% for a double side patterned substrate.

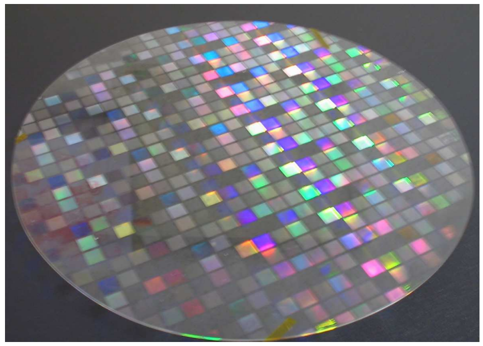

Figure 1: Optical picture of the 8’’ Polycarbonate surface covered with imprinted pillars

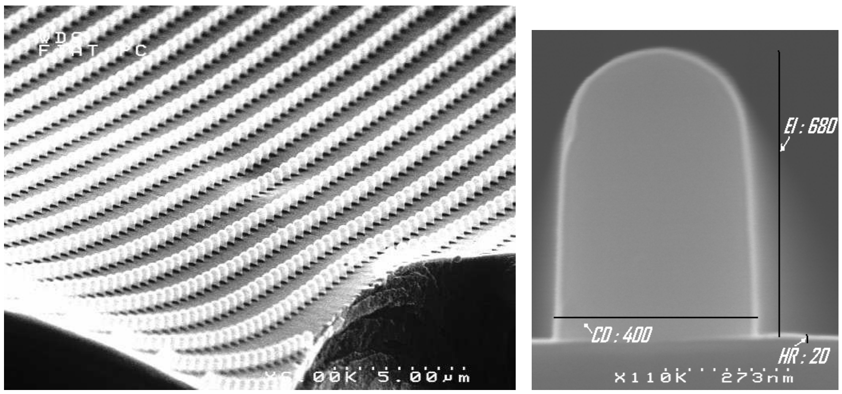

Figure 2 : 680 nm high pillars imprinted in Polycarbonate

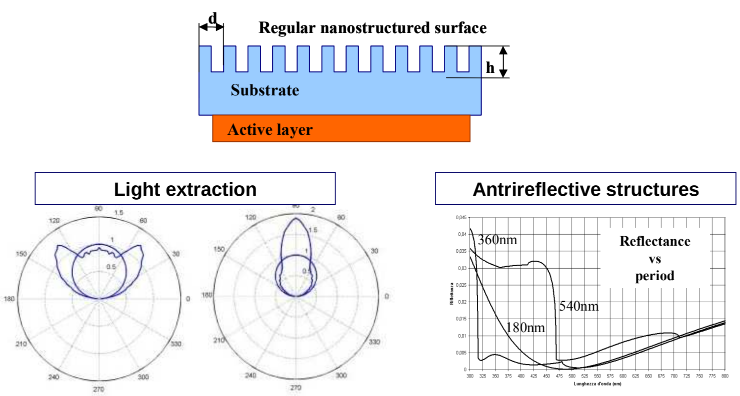

Figure 3 : Nanostructured surfaces for optical applications

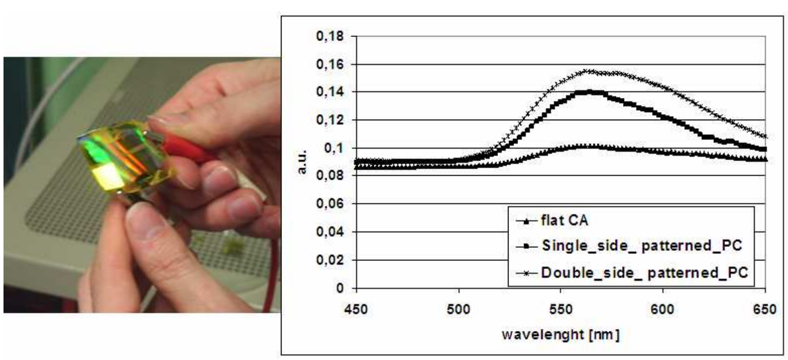

Figure 4: OLED device based on NIL plastic surfaces and electro-optical characterization