58nm Half-Pitch Plastic Wire-Grid-Polarizer by Nano-Imprint Lithography

Lei Chen, Jian Jim Wang, Frank Walters, Xuegong Deng, Mike Buonanno,
Stephen Tai, Xiaoming Liu
NanoOpto Corp., 1600 Cottontail Lane, Somerset, NJ 08873

Nano-wire-grid polarizer (NWGP) is an optical component based on the nano-metal gratings on the surface. On NWGP, the incident light with polarization parallel to the metal grating is reflected, while the one perpendicular to the metal gratings, is transmitted. NWGP has demonstrated good polarization efficiency, wide view angle, long-term stability and the potential to integrate with other optical components [1,2]. NWGPs with 100 and 75nm half-pitch metal gratings on glasses have been commercialized [3,4]. For the applications in visible and even shorter wavelengths, around 50nm half-pitch gratings are recommended [5]. However, the fabrication of such small gratings is a challenge to the existing lithography technologies.

In this study, small period (58nm half-pitch) polymer gratings over large area (4-inch. diameter) on the flexible plastic film are successfully fabricated by nano-imprint lithography (NIL) [6]. Al is selected as the metal for our NWGP and is deposited on the sidewall of the plastic gratings at oblique angle. The fabricated NWGP is shown in figure 1. In contrast to the glasses, plastic sheets are cheap, flexible and can scale up to large area easily. Large and flexible are the directions of the commercial display market. Therefore, the development of plastic small pitch NWGP used in visible band is of a great relevance to the real applications.

The effect of the pitch reduction is studied first. Compared to 75nm half-pitch gratings, 58nm ones provide higher maximum transmittance (Tmax) and better extinction ratio (ER) to the NWGP. ER seems more sensitive to the grating period than the Tmax. Besides the grating period, the grating line width is also important to the performances of NWGP. It is known that the light reflection decreases with the metal grating line width. Therefore the line width reduction increases the Tmax of NWGP. For the same pitch gratings, the reduction in grating line width increases the line spacing. Al goes deeper on the grating sidewall when line spacing is wider. The deeper Al on the sidewall corresponds to the thicker Al and exhibits higher ER. To further explore the effect of Al on the grating sidewall, a variety of Al depth was deposited and studied. It is confirmed that the deeper the Al, the higher the extinction ratio will be. On the other hand, as Al goes deeper on the sidewall, the Al on the grating top is getting thinner. The good news is that the thinner top Al favors to achieve higher Tmax.

It is interesting to see that Tmax and ER can be improved simultaneously by reducing the grating period, grating line width or Al shadow angle. Excellent contrast ~30dB and high transmittance (80%-90%) (without anti-reflection coating) are demonstrated (as shown in figure 2).

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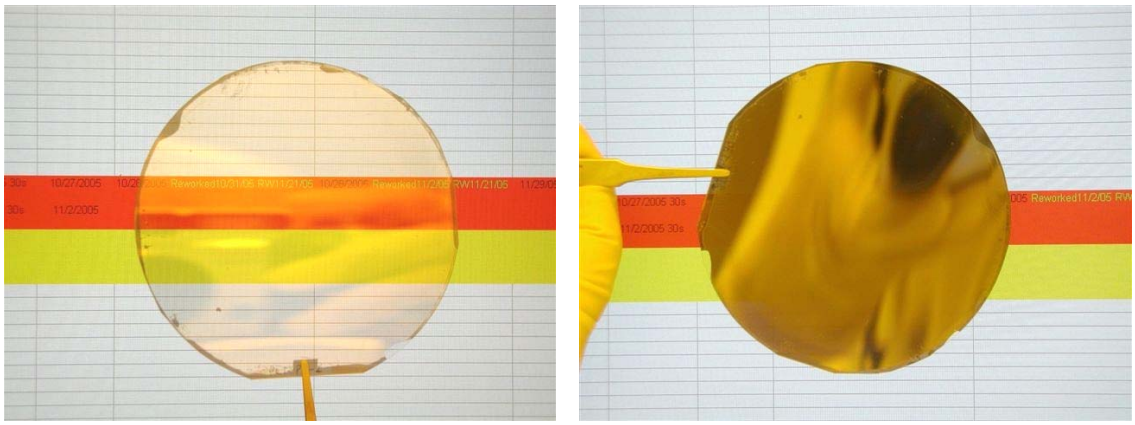
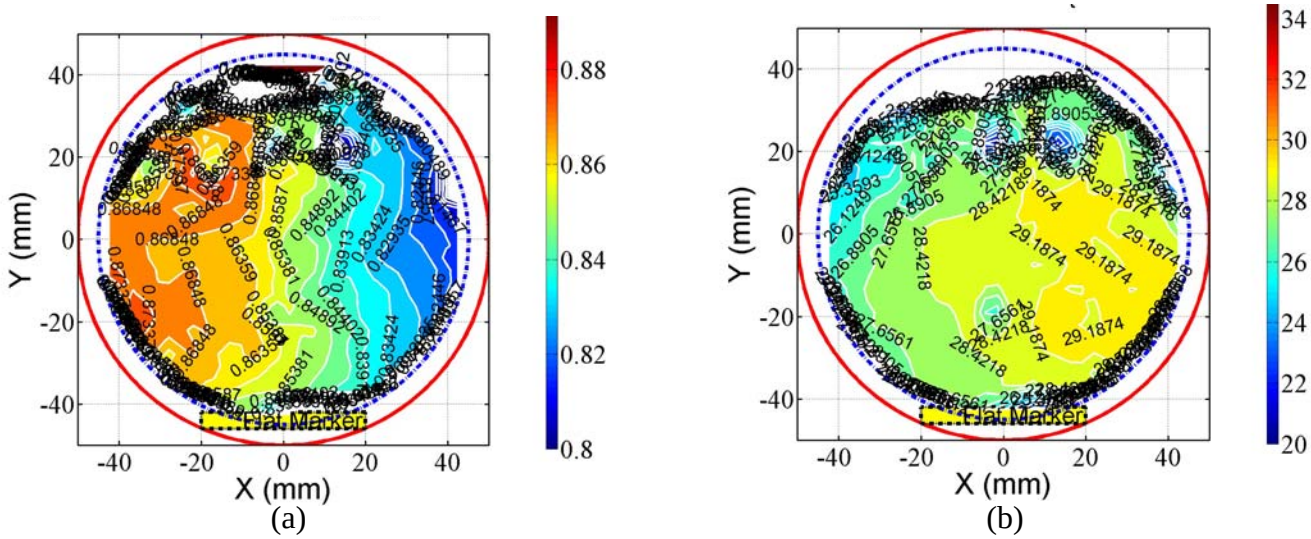


(a) (b)

Figure 1. Plastic visible polarizer made by NIL
(a: maximum transmittance; b: contrast demo.)



(a) (b)

Figure 2. Tmax (a) and ER (b) wafer map of the selected NWGP at 650nm