A Study of Nanoimprinted Color Filter with Ultra High Resolution

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Plasmon resonance induced extraordinary optical transmission (EOT) in metal films is capable of color selection in full color spectra without degradation by the UV radiation, which may lead to wide applications in photonic circuit components, optical data storage, macroscopic color holograms, chemical sensors, full-range color filters and displays, and polarizers, etc. Although substantial basic study in both proof-of-concept and nanofabrication techniques have been reported, nanofabrication techniques are still limited to single device fabrication as a laboratory demonstration. Nanoimprint lithography can be one of the candidates for the scale-up in industry. However, as shown in figure 1 for process flow, after imprint of hole array in plastics, a flood deposition of metals always leave discs on the bottom of holes, whose effect on the transmissions of light is the main topic in this work. Will the discs block the transmission? What is the optimum geometric configuration? What is the color selection behavior with the existence of the discs. It is belied that the process depicted in figure 1 is the simplest technique with lowest cost for the scale up manufacturing. However, before it is commercialized, the transmittance nature of such a sub-wavelength hole array in metals must be fully understood.
In our work, Nanoimprint Lithography (NIL) is used in association with a one-layer metal deposition to achieve a RGB color filter in ultrahigh resolution of 25,000 dots per inch (DPI). A series of templates is fabricated by EBL. The nanostructures are then imprinted into the SU-8 resist on a quartz substrate. In order to understand the relationship between the margin of error in the imprint depth and the color output deviation, a series of Finite Difference Time Domain (FDTD) simulations are carried out and the transmission spectra show that the output has negligible difference when the imprint depth of the EOT structure changes from 150 nm to 1000 nm while keeping the other structural parameters the same. With a systematic FDTD simulation, the three primary colors, Red, Green and Blue, are all achieved with reasonable change of diameter/period of the EOT structures. When the actual sample is fabricated, the transmission and reflection photos show complimentary colors as predicted by simulation.

We conclude that this simple fabrication method can be used to produce ultra high resolution color filter with high throughput and low cost for industries in color display, sensing and imaging.

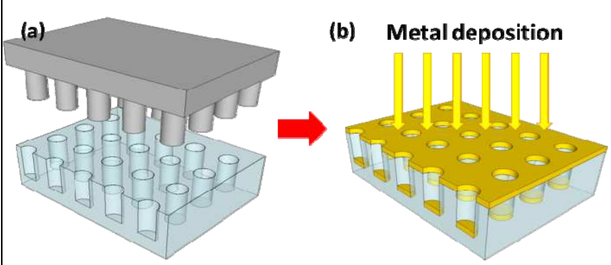

Figure 1. two-step process flow to fabricate the sub-wavelength hole arrays combined with a nanoimprint process and metal deposition.

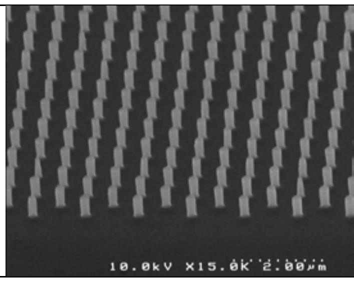

Figure 2. the nanoimprint template fabricated by EBL.

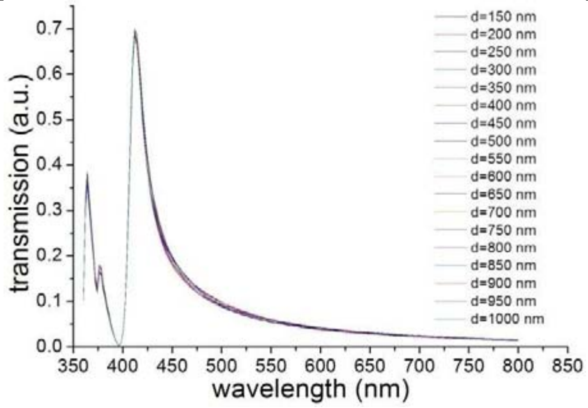

Figure 3. The simulated transmittance for structures with different hole imprint depth from 150 nm to1000 nm

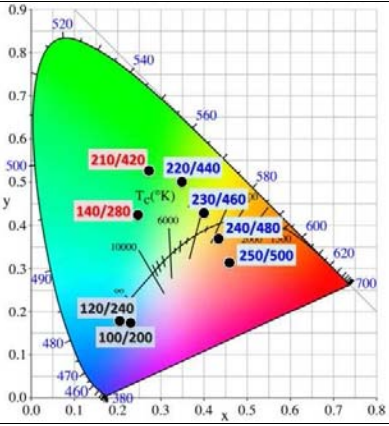

Figure 4. chromaticity diagram for RGB primary color achieved by various diameter/periods of the EOT hole arrays.

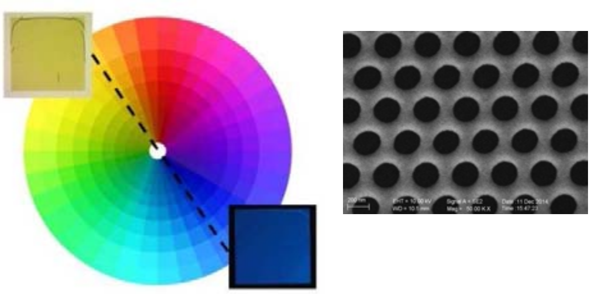

Figure 5. microscopic photos of complementary colors from the same structure in the SEM picture from reflection (yellow) and transmission (blue). The structure is a 210nm/420nm hole structure with 100 nm Al film deposition.

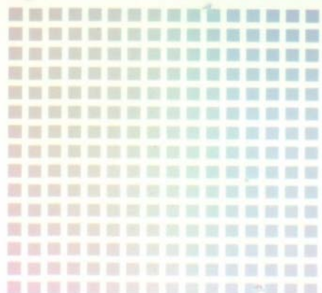

Figure 6. The microscopic picture of an array of EOT structures with different diameter/periods before metal deposition. The whole pallet is achieved, though not vivid. Each square is 100 μm^2 in size.