Transmissive Color Filters Fabricated Using Pattern Transfer Lithography

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Color filter technology has become a prime research area with the prevalence of complementary metal-oxide-semiconductor (CMOS) image sensors, projection systems, light emitting diodes, and liquid crystal displays. In recent years, scientists have focused on novel patterns and techniques to produce transmission color filter devices without the use of thick polymer layers and absorbing dyes which can increase power consumption and are not compatible with CMOS technology. During this time, subwavelength gratings have gained a large amount of attention due to their ability to filter white light by altering the period along with the opportunity to produce small pixels over large areas by utilizing nanoimprint lithography methods [1][2].

We exploited a metal-insulator-metal structure at visible frequencies similar to that in [3] but we propose to use a grating to couple incident light into supported plasmon modes, and another grating is used to scatter the confined plasmons into propagating waves in free space in the forward direction. Our goal is to increase the transmission amplitude by several orders of magnitude to that in [3] so it can be used in practical applications. Figure 1 shows a diagram of the fabricated structure. Our simulations show that the line dimensions, materials, and period of the structure can be altered to select specific visible colors for transmission.

To create the structure, a pattern transfer technique from a pre-patterned stamp was employed [4][5] (Figure 2). An initial SiO_2 mold was fabricated and then coated with a fluorosilane surfactant to reduce adhesion of the pattern to the substrate. Ag was first deposited on the mold followed by a layer of TiO_2, and finally another layer of Ag. Using specific temperature and pressure conditions, this pattern was then transferred to PMMA spin-coated onto a fused silica substrate. This method will allow for large area production while permitting small pixel sizes. Furthermore, the structure itself is easily repeatable, relying only on the period of the mold and deposition conditions.

The initial result using an existing 200 nm period grating along with the simulated and measured transmission spectra are shown in Figure 3 with both showing a peak in the light blue region. TM refers to the transverse magnetic mode (orientation shown in Figure 1). Future work will focus on achieving higher transmission and a sharper resonance by utilizing new materials and different period molds in the hopes of fabricating structures that could be used for red, green, and blue pixels for use in display technologies.

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[2] Kanamori, Y., Shimono, M., Hane, K., *IEEE Pho. Tech. Lett.* **18**, 2126-2128 (2006).

[3] Diest, K., Dionne, J.A., Spain, M., Atwater, H.A. *Nano Lett.***9**, 2579-2583 (2009).

[4] Kang, M.G., Guo, L.J., *J. Vac.Sci. & Technology B* **25**, 2637-2641 (2007).

[5] Kang, M.G., Guo, L.J., *J. Vac.Sci. & Technology B* **26**, 2421-2425 (2008).

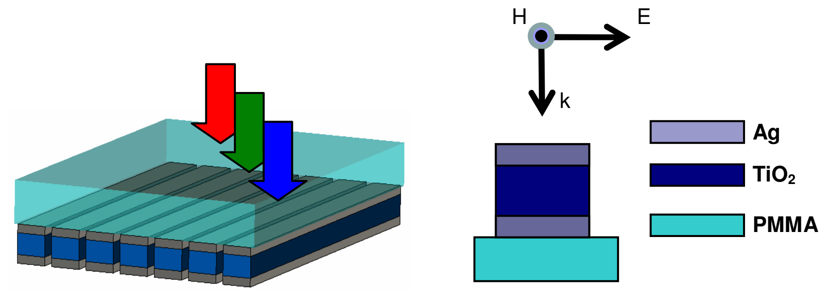

Figure 1: Diagram of fabricated structure with the transverse magnetic (TM) mode shown.

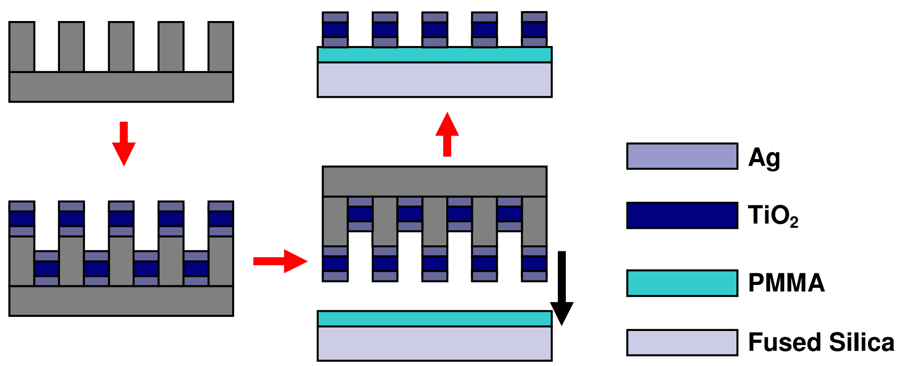

Figure 2: Diagram showing the processing steps to create transmission color filter structure.

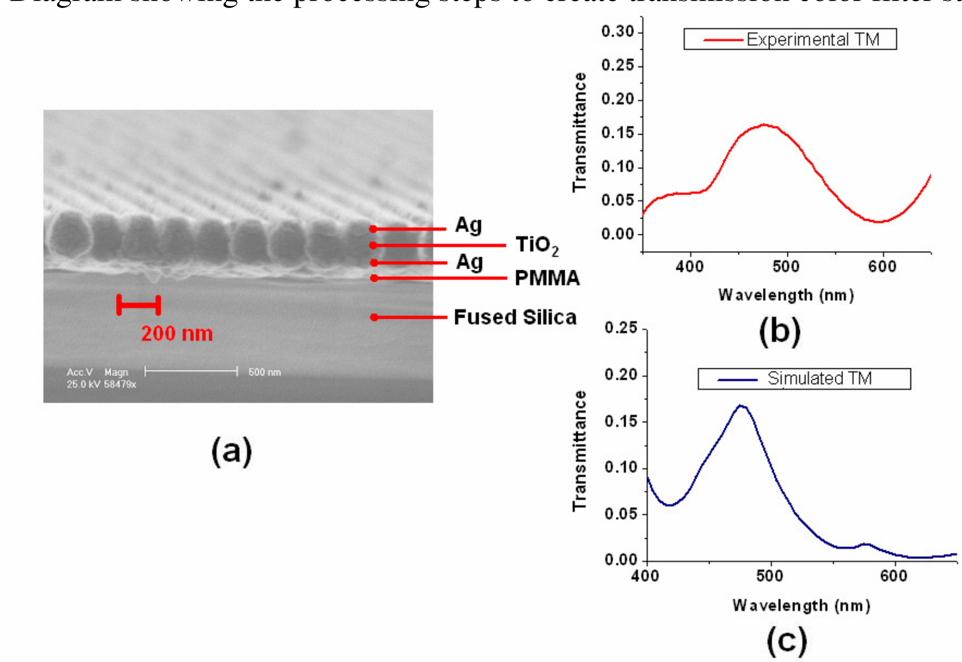

Figure 3: SEM image of the structure (a) along with the measured (b) and simulated (c) transmission spectra for TM mode.