High Efficiency Plasmonic Color Filters Fabricated Using Imprint Lithography

Alex F. Kaplan, **Ting Xu, L. Jay Guo**
Center for Nanophotonics and Spintronics
Department of Electrical Engineering and Computer Science
University of Michigan, 1301 Beal Avenue, Ann Arbor, MI 48109, USA

Color filtering devices are currently in demand for applications such as liquid-crystal displays, light emitting diodes, and image sensors, among others, but each of these applications has its own particular requirements. Numerous groups have investigated thin-film nanotechnologies to meet some of these demands and replace the thick colorant polymer layers which typically dominate the field. For this reason, the highest peak transmission and efficiency of a thin-film color filter is of primary interest. Depending on the specific applications, some technologies also desire simultaneous polarization of the transmitted light while others may require narrow spectral peaks for highly specific wavelength filtering [1][2].

We have recently presented results [3] for a thin, metal-insulator-metal (MIM) grating structure fabricated using focused ion beam which could filter light over a specific band simply by changing the period of the structure while simultaneously polarizing the outgoing light. However, for large-scale production, we employ nanoimprint lithography to fabricate these structures over large areas. For this purpose we have designed alternative structures which are better suited for such a fabrication process.

In Figure 1, we present a hybrid plasmon waveguide structure with a single patterned Al layer on top of dielectric deposited on a glass substrate. This robust, easy to fabricate structure can produce various spectra depending on the desired application by altering the period, linewidth, and thickness of the Al grating or by changing the continuous dielectric layer. In Figure 2, two simulation sets are presented for different applications. The first structure which features a thick Al grating and high index dielectric (Figure 2a) is targeted for polarizing applications such as liquid crystal displays where transverse magnetic (TM) polarized light will be transmitted with ~50% efficiency at the peak while transverse electric (TE) light is almost completely suppressed (<1%). The second which has a thin Al grating and lower index dielectric (Figure 2b) shows a narrower spectral peak with high transmittance near ~90% at the peak wavelength. Figure 3 shows some initial experimental results and images from fabricated structures which display good agreement with simulations. We are working toward reaching the peak transmission efficiencies and spectral widths predicted by the simulations.

---

[1] Q. Chen and D.R.S. Cumming, *Opt. Exp.* **18**, 14056-14062 (2010).
[2] Y. Ye, H. Zhang, Y. Zhou, L. Chen, *Opt. Comm.* **283**, 613-616 (2010).
[3] T. Xu, Y.K. Wu, X. Luo, L.J. Guo, *Nat. Comm.* DOI: 10.1038/ncomms1058 (2010).
[4] S.H. Mousavi, A.B. Khanikaev, B. Neuner III, Y. Avitzour, D. Korobkin, G. Ferro, G. Shvets, *PRL* **105,** 176803 (2010).

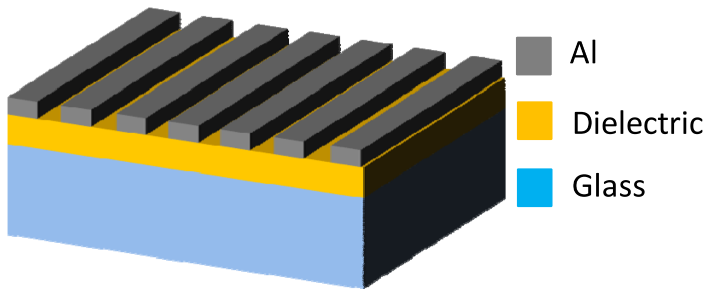

Figure 1: Basic diagram of thin-film color filter structure.

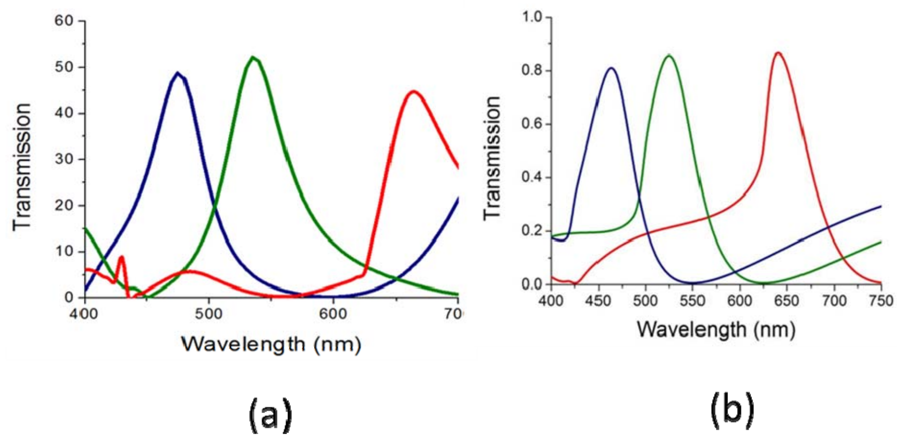

Figure 2: TM transmission simulation results for (a) thick Al, high index dielectric, polarizing structure (b) thin Al, lower index dielectric, high transmission structure.

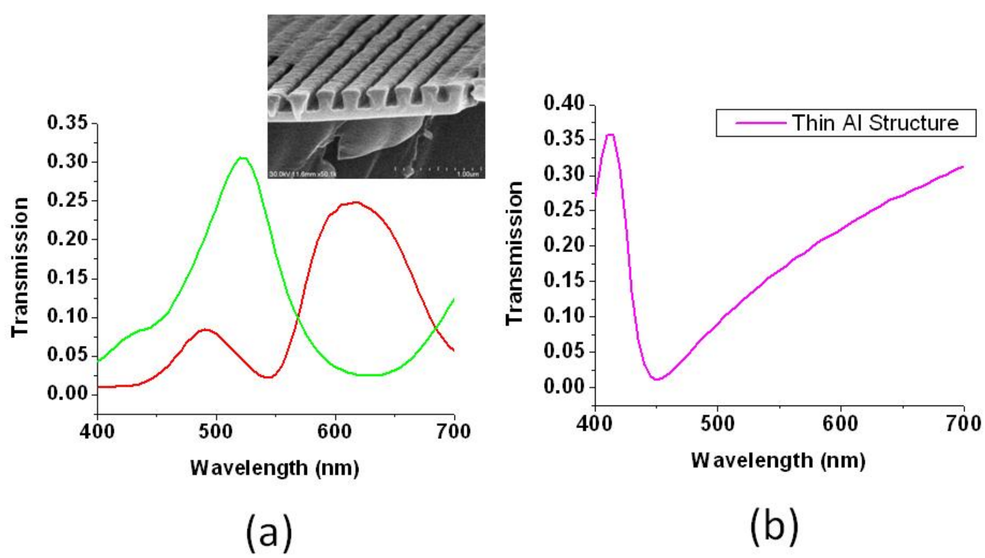

Figure 3: TM transmission experimental results for (a) green and red polarizing filters (SEM image inset) and (b) high transmission structure.