Vibrant color transmission under cross-polarization through gold-coated nanoimprinted gratings on polymer foils

K.J. Morton, T. Veres
Nanofunctional Materials Group, National Research Council Canada
Montreal, QC, Canada, J4B 6Y4
keith.morton@nrc.gc.ca

Recently, progress in nanofabricated, optically active plasmonic elements has renewed interest in nanostructured color filtering[1]. Advantages include a planar, thin-film format, mechanical robustness and the avoidance of bleachable dyes. Here we report on the fabrication and characterization of gold-coated transmission gratings on polymer foils and substrates, which, under cross-polarization, exhibit vivid color filtering.

Nanostructured gratings and 2D post arrays (Fig. 1) were imprinted directly into all-polymer substrates using the EVG750 (EVGroup, Austria) automated hot embossing machine. Polymer wafers are handled automatically from cassette to press and back using a robot arm with automated de-embossing[2]. Replica-cast, uv-cured, polymer working stamps are made from silicon master molds and are pre-mounted in the press. Direct patterning of nanostructures on transparent polymer substrates eliminates the need for spun-on resists, lift-off, etching or pattern transfer. Metallization is simply conformal with 10-50nm thick gold deposited by sputtering onto the nanostructured polymer substrates.

White light transmission through the optically active plasmonic structures was characterized for various (normally) incident polarizations and azimuthal substrate angles using a polarizing microscope (Nikon UV-POL) with either a color CCD (Qimaging R2000) or fiber-coupled spectrometer (Ocean Optics.) A CCD image of cross-polarized light transmission through a grating sample is shown in Fig 2. A 50 nm gold layer was deposited everywhere in field of view, but appears black under the cross-polarization condition where the analyzer is rotated exactly 90° to the incident polarizer. The vibrant color bandpass is limited to the 1mm x 2mm region structured with a 500nm pitch grating. Figure 2b shows a green-yellow transmission, again in cross polarization, through a 50nm gold layer on a 200nm pitch 2D grating.

Functional optical topologies were fabricated simply, by direct nanoimprint, using working stamps to structure polymer foils and substrates. When gold-coated, the nanostructures exhibit vibrant color transmission under observation with cross-polarized light and provide a new route to ultrathin, durable, non-bleaching and low-cost color transmission filters.

[1] T. Xu , H. Shi , Y.K. Wu , A.F. Kaplan , J.G. Ok, and L.J. Guo, Small, 7, 22, Sept 2011
[2] T. Glinsner, T.Veres, G. Kreindl, K. Morton, E. Roy, T. Wieser, C. Thanner, D. Treiblmayr, R. Miller, P. Lindner, Microelectronic Engineering, Volume 87, Issues 5-8, pp 1037-1040 (2010).

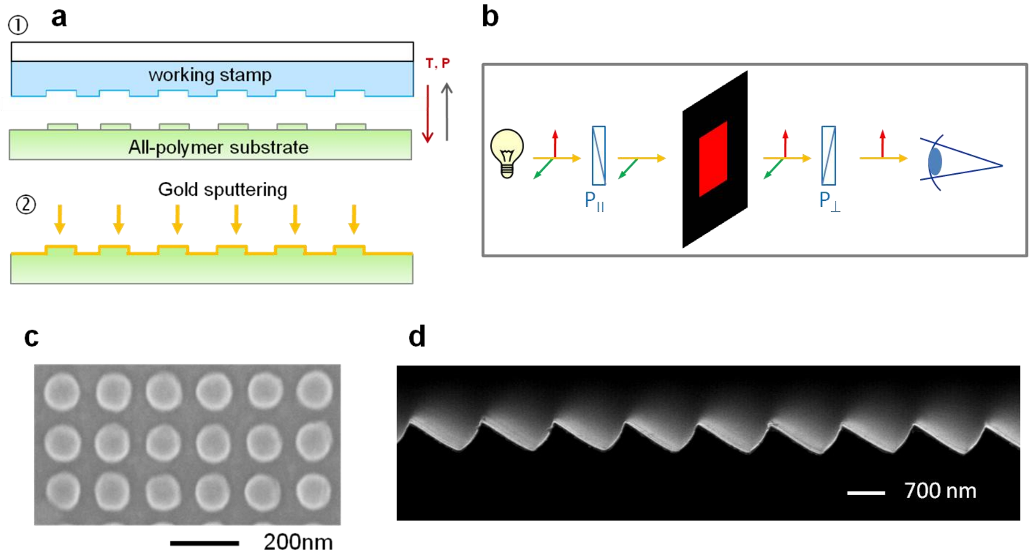

Figure 1: a) Plastic substrates are structured by direct imprint and then conformally coated with gold without the need for pattern transfer or lift-off. c,d) SEM images showing nanoimprinted and gold-coated grating structures: c) Top view 200nm pitch 2D grating array and (d) cross-section of directly imprinted saw-tooth grating with 700nm pitch. b) Schematic of experimental set-up showing sample imaging between two crossed polarizers.

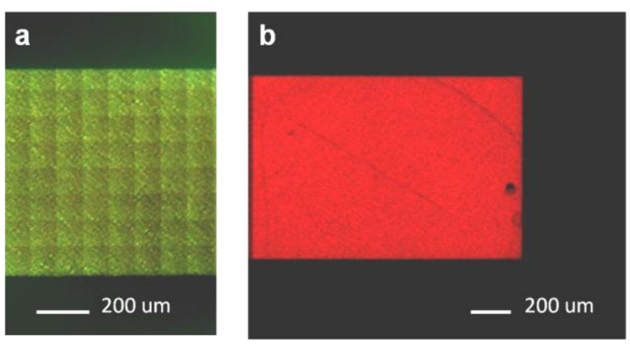

Figure 1: a) CCD image showing light transmitted through a 200nm grating structure under the cross-polarization condition shown in Fig. 1b. Here the sample is rotated continuously relative to the input polarization until the maximum transmitted intensity is reached. Gold is deposited everywhere, throughout the field of view, but unstructured, it appears black when the analyzing polarizer is rotated 90° relative to the input polarizer. b) Equivalent CCD image of transmitted light through a 500nm pitch grating.