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Multipolymeric planar optical waveguides for wavelength converters and biosensing application

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Abstract – This study describes the fabrication of Multipolymeric Optical Waveguides (MPOW) based on PMMA matrix containing different luminescent polymers. These planar luminescent waveguides possess the unique characteristic of emitting very narrow lines which are completely tunable by changing the waveguide geometry, the effective diffraction index and by controlling the optical process between the constituent emitting molecules. These unique characteristics are attractive for devices in optoelectronics, photonics and for sensor applications.

We demonstrate that wavelength selective planar waveguides can be produced with blends consisting of different luminescent polymers embedded in a poly(methyl methacrylate) matrix. The advantage of using a multipolymeric waveguide is the ability of tune the spectral emission simply by choice of suitable polymers and their relative concentration in the solid polymethacrylate matrix. Our results show that high luminescence quantum efficiency can be observed for the polymers since very low solid dilution without molecular aggregation is achieved with polymethacrylate. Here, we used five polymers having emission superposition in the range from 400 nm to 600 nm (Figure 1). The planar waveguide is formed by a reflecting aluminum layer deposited on a glass substrate which was covered by the polymethacrylate film (~1μm). The luminescence originated itself from the broad emission of all polymers (insert of Figure 2). However, this architecture is enough to couple very narrow (FWHM~5nm) transverse electric TE and transverse magnetic TM modes propagating along the guide plane. Figure 2a compares the guide emission modes (TM and TE) collected laterally from the device plane (sharp peaks) and the luminescence detected from the top (broad emission) which has no guide signature. These modes are strongly polarized, as can be seen in Figure 2b. The spectral position and shape of these narrow waveguide emissions are highly sensitive to the change of the effective optical thickness. We demonstrate that enzyme immobilization on the top of the polymeric waveguide displaces the narrow waveguide modes through the change of the effective diffraction index of the guide allowing the application as biosensor (Figure 2c). The waveguide effect can be also used as wavelength converters, since all light absorbed by the can be emitted at a single wavelength. The propagating light along the waveguide is strongly reabsorbed, producing an effective redistribution of emission patterns that results in a single narrow luminescence displaced to the red. These full polymeric waveguides can be exploited as unconventional wavelength converters for new generation of solar concentrations and in biosensing application.

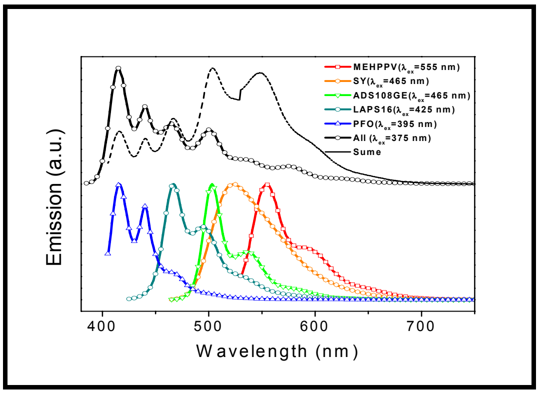

Figure 1: Luminescence spectra of five polymers and PMMA in toluene solution (lower spectra). The upper spectrum shows the superposition of the emission of al polymers in toluene solution.

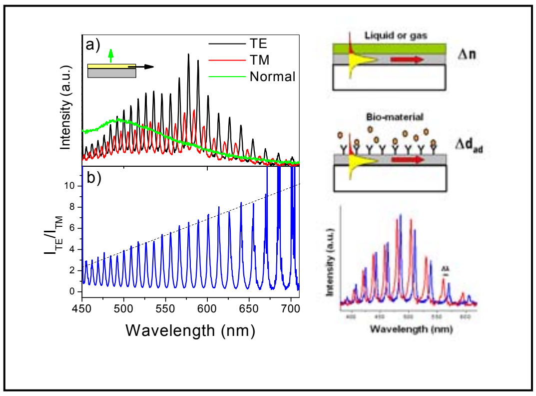

Figure 2: a) Waveguide emission modes (TM and TE) collected laterally to the device plane and the emission collected from the top (normal emission) which has no guide signature. b) Emission polarization calculated from the two guide modes TE and TM.