Engineering light transport in titania-doped multifunctional elastomers

André Espinha,[a] María Concepción Serrano,[b] Álvaro Blanco,[a] Cefe López[a]

[a]Instituto de Ciencia de Materiales de Madrid (ICMM-CSIC),
Calle Sor Juana Inés de la Cruz 3, Cantoblanco, 28049 Madrid, Spain
[b]Hospital Nacional de Parapléjicos, Finca de la Peraleda s/n, 45071 Toledo, Spain
acmespinha@icmm.csic.es

Abstract

Composites incorporating an optically functional phase embedded in polymeric matrices are a platform of choice for the development of optical systems such as flexible, transparency preserving materials with high refractive index [1]. In these cases, the size of the fillers is usually much smaller than light wavelength, so that scattering is minimized. To facilitate the high refractive index, titania nanoparticles are frequently selected [2]. On the other turn, the Mie regime is reached if the size of the particles is of the order of the wavelength, situation in which the scattering is significantly enhanced. Due to multiple scattering [3], light transport on those media becomes diffusive.

Important advances have been realized in the materials community in search for multifunctional features impacting the performance of systems and devices and, in this sense, photonics is not an exception. As an example, we recently reported the possibility of programming the lattice parameter of a two dimensional photonic crystal [4] by making use of multifunctional shape memory polymers [5]. While well-ordered structures are essential in photonic crystals, disordered materials, presenting diffusive transport, may be also extremely interesting [6] and they have proven impact on applications such as random lasers or imaging through opaque media.

In this work [7], we fabricated elastomeric composites by embedding titania particles with an average size of *ca*. 230 nm in a shape memory polymer belonging to the family of polydiolcitrates. As shown by modulated differential scanning calorimetry, these composites displayed a melting transition in range with previous reports [8], which is responsible for the physical switching mechanism originating the shape memory effect. Depending on the temperature or on the concentration of fillers, the proposed materials may be highly translucent or opaque. The light transport, specifically the transport mean free path, was characterized using coherent backscattering measurements and shown to depend on the amount of titania incorporated.

The reported composites may find application as a new kind of actuators or as part of novel programmable materials for exploring new avenues in photonics.

This work was partially supported by EU FP7 NoE Nanophotonics4Energy grant No. 248855, the Spanish MICINN project MAT2012–31659 (SAMAP), and Comunidad de Madrid S2009/MAT-1756 (PHAMA) program. A.E. was supported by the FPI Ph.D. program from the MICINN. M.C.S. acknowledges Instituto de Salud Carlos III - MINECO for a Miguel Servet contract (CP13-00060).

References

[1] L. Beecroft, C. Ober, Chemistry of Materials, **9** (1997) 1302.
[2] A. Chandra, L. Turng, S. Gong, D. C. Hall, D. F. Caulfield, Polymer Composites, **28** (2007) 241.
[3] B. Van Der Mark, M. P. Van Albada, A. Lagendijk, Physical Review B, **37** (1988) 3575.
[4] A. Espinha, M. C. Serrano, A. Blanco, C. López, Advanced Optical Materials, **2** (2014) 516.
[5] M. Behl, M. Razzaq, A. Lendlein, Advanced Materials, **22** (2010) 3388.
[6] D. S. Wiersma, Nature Photonics, **7** (2013) 188.
[7] A. Espinha et al. Submitted (2015).
[8] M. C. Serrano, L. Carbajal, G. Ameer, Advanced Materials, **23** (2011) 2211.