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# Photothermal Microscopy Applied to the Study of Polymer Composites

Facundo Zaldivar Escola[1,2*], Nélida Mingolo[1]

[1.] Laboratorio de Haces Dirigidos, Departamento de Física, (FIUBA), Buenos Aires, Argentina.

[2.] Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Buenos Aires, Argentina.

* Corresponding author: facundozaldivar@gmail.com

The applications of polymers have grown with the beginning of the new century. Today there are many uses in all types of areas, such as coatings, adhesives, structural materials, engineering materials, packaging, clothing, solid supports for organic synthesis, biomedicine, prostheses and their emerging applications in additive manufacturing (3D printing).

This huge field of applications leads to the constant development of new materials with improved properties for each purpose, as is the case of polymers based micro or nanocomposites that in recent years have been used in many industrial fields. They allow an improvement of the properties of the pure polymer such as its rigidity or can add some properties that are almost non-existent in raw materials, such as gas permeability, fire resistance, electrical and thermal conductivity [1, 2].

The appearance of new materials presents the challenge of developing new versatile techniques for their characterization. In particular, the mechanical and thermodynamic properties require the development of specific techniques that discriminate the surface from the volume or even determine the gradient of properties generated by material treatments. This discrimination becomes particularly difficult when the substrate is of the same composition as the treated zone.

Previous works of the group showed that methods based on photothermal techniques can display a high contrast between the different phases due to their distinct thermal diffusivity. Mapping structures with micrometric resolution, the study of homogeneity, composition and phase transformations in a diverse set of materials such as ceramics, metals, glass and thin layers have been achieved [3-6].

In this work we propose to transfer the capabilities of a high sensitivity photothermal technique, developed by the group and called Photothermal Microscopy [7], to the study of polymer composites. This technique uses a probe beam for the measurement of the thermal response of the sample due to local effects induced by heating with a modulated pump laser. With a simple spatial sweep of the beams on the surface of the sample, information on a micrometric scale of the thermal diffusivity of the material, distribution of phases and pores can be obtained. Very low powers are used, in the order of the microwatts, so the material is not affected by the study, allowing multiple sweeps carried out in the same area without any degradation or changes being observed.

Fig. 1 shows a sweep with micrometric resolution on a sample consisting of a polypropylene (PP) matrix with 5wt% of quartz particles, with a particle size distribution ranging from submicron values to 8.5µm, used as reinforcement. The area without a signal either by the presence of pores or quartz is plotted in white. From the thermal diffusivity map the distribution of crystalline phases and amorphous can be established. By post-process analysis average values of thermal diffusivity, percentage of crystallinity, distribution of aggregates can be obtained.

References:


[1] B. Weidenfeller, M. Anhalt, S. Kirchberg, J. Appl. Phys. **112** (2012), p. 093513.

[2] M. Gresil et al., Scientific Reports **7** (2017), p. 5536.

[3] U. Crossa Archiopoli, N. Mingolo, O.E. Martínez, J. Appl. Phys. **107** (2010), p. 023520.

[4] F. Zaldivar Escola et al., Procedia Mater. Sci. **8** (2015), p. 665.

[5] F. Zaldivar Escola , R. Kempf, N.Mingolo, O. E. Martínez, Int. J. Thermophys. **37**(20) (2016), p. 1.

[6] F. Zaldivar Escola, O. E. Martínez, N. Mingolo, Rev. Mat. **23** (2) (2018). p. 1.

[7] N. Mingolo, O.E. Martínez, J. Appl. Phys. **111**(12) (2012) p. 123526.


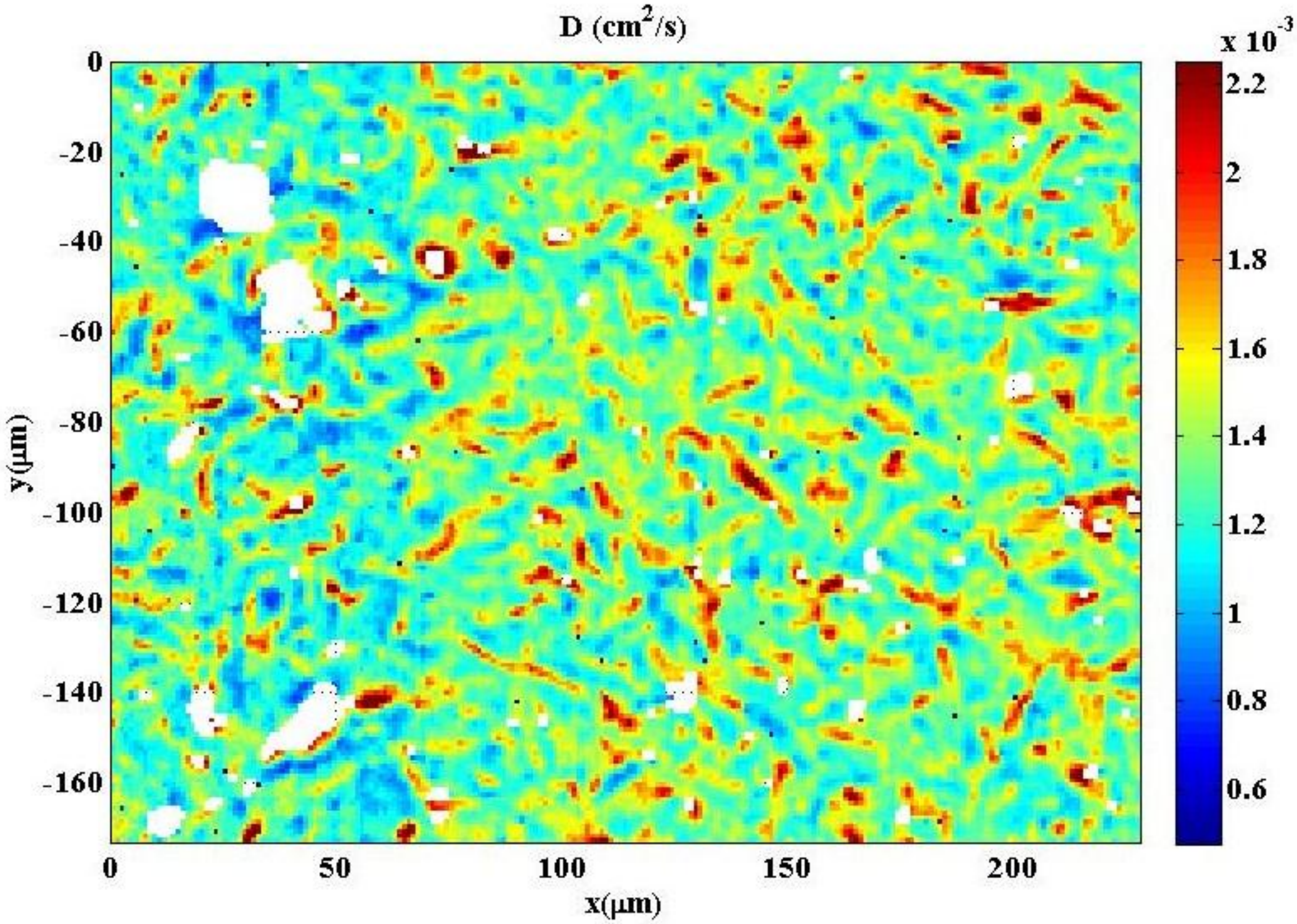


**Figure 1.** Diffusivity map of PP+5%$SiO_2$. It can be seen the distribution of crystalline phases (zones with vermicular shape of larger diffusivity) and amorphous (lower diffusivity background).

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