IR Thermography applied to assess thermophysical properties of doped polyaniline for thermoelectric applications

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Abstract

Harversting the waste energy is attracting the interest of researchers in the field of thermoelectric materials and devices. The development of new thermoelectric materials is moving to organic ones to exploit low temperature (T<150°C) waste heat recovery. Among organic thermoelectric materials, polyaniline is particularly taken into consideration for its intrinsic electrical conductivity. After suitable p-n doping, polyaniline can be arranged as a thermocouple exhibiting interesting values of both electrical conductivity and Seebeck coefficient. Moreover, the possible manufacturing of such materials in light, thin and flexible sheets makes them easily integrated into unusual topologies to fit the geometrical requirements of applications spanning from wearable electronics to power supplies for mobile devices. Nonetheless the figure of merit, that characterizes the efficiency of the energy conversion (heat to electrical energy), for such materials is still far from the values reached by classical inorganic materials like Bi_2Te_3, PbTe, SiGe and Sb_2Te_3 [1-5]. Thermal conductivity λ must be determined, together with electrical conductivity σ and the Seebeck coefficient α, to evaluate the figure of merit ZT, according to the following equation:

$$ZT = \frac{\alpha^2 \sigma T}{\lambda} \tag{1}$$

where T is temperature in Kelvin.

Thermal conductivity, in the synthesis of these polymeric material, is anisotropic [6]. IR thermography, thanks to its imaging capability is an interesting instrument to carry out photothermal experiments that allows the characterization of both the thermal conductivity components of an orthotropic material. Two active thermography techniques are considered. In the first a laser pulse, spatially localized, heats the material under test. IR thermography collects a sequence of images of the transient phenomena that are spatially decomposed by means of the Fourier Transform and successively analysed in time to determine the thermal diffusivity. In the second, a laser source is modulated to produce thermal waves. The temperature field is successively analysed in phase and amplitude to retrieve the two components of thermal diffusivity, in-plane and through the thickness. The measurement of the specific heat and the density allows for the assessment of thermal conductivity in the two aforementioned directions.

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