



**HAL**  
open science

## Optical constants ( $n$ , $k$ ) extraction from R, T measurements in organic thin film

Victorien Raulot, R Clerc, M Hebert, B Bouthinon, Jean-Marie Verilhac

### ► To cite this version:

Victorien Raulot, R Clerc, M Hebert, B Bouthinon, Jean-Marie Verilhac. Optical constants ( $n$ ,  $k$ ) extraction from R, T measurements in organic thin film. International Conference on Organic Electronics, Jun 2015, Erlangen, Germany. hal-01217401

**HAL Id: hal-01217401**

**<https://hal.science/hal-01217401>**

Submitted on 19 Oct 2015

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

## Optical constants (n, k) extraction from R, T measurements in organic thin film

V. Raulot<sup>1</sup>, R. Clerc<sup>1</sup>, M. Hebert<sup>1</sup>, B. Bouthinon<sup>2</sup>, J.M. Verilhac<sup>3</sup>

<sup>1</sup>Laboratoire Hubert Curien, UMR CNRS 5516, Université Jean Monnet Saint-Etienne, and Institut d'Optique Graduate School, France, <sup>2</sup>Isorg, 7 parvis Louis Néel, BP 50, 38040 Grenoble Cedex 9, France, <sup>3</sup>CEA Liten-DRNM-LCH, 17 rue des Martyrs, 38054 Grenoble Cedex 9, France

Corresponding author: [raphael.clerc@institutoptique.fr](mailto:raphael.clerc@institutoptique.fr)

The characterization and modeling of Organic PhotoVoltaic (OPV) devices, generally composed of several layers of organic materials, typically requires an accurate determination of optical constants (n,k) [1]. Several approaches have been proposed to this aim, mostly using spectrophotometric measurements, such as ellipsometry [2] and reflectance and transmittance [3]. The real challenge for both techniques is the n and k extraction from measurements, especially when n and k are potentially of the same order of magnitude, and/or strongly varying with the wavelength, as in most organic materials used in OPV [4]. Indeed, for these materials, the simplest extraction techniques cannot be used. The envelope method [5] for example is limited to low absorbing materials. Moreover, multi-wavelength approaches usually require to know a-priori an equation for the dispersion model ([6]) (Cauchy equations, Sellmeier relations or a limited number of Lorentz oscillators). In consequence, a brute-force numerical inversion method has to be used to deduce (n,k) from measurements, which is known to lead to multiple solutions [7], requiring additional information to select the true (n,k) value from all multiple solutions.

The aim of this paper is to propose an original and complete methodology to extract n and k from R, T measurements without making any a-priori assumption. The proposed methodology is summarized in the following. 1/ R, T measurements are first performed on the substrate (typically an optical glass) 2/ As in [5], two samples are processed, featuring the same material, but two different thicknesses, accurately measured. 3/ Transmittance and reflectance measurements are performed thanks to a Perkin Elmer lambda 900 spectro-photometer. 4/ several techniques are performed to deduce (n,k) from measurements. First of all, approximated (n,k) values are extracted from incoherent formulas (ray optics). Even if this approach is in principle inaccurate in thin layers featuring strong interference effects, it does not suffer from multiple solutions, and usually gives good guess values for more rigorous approaches, especially for thick or strongly absorbing layers. Then, for ultra-thin layers ( $n \ll \lambda$ ), we use the brute-force numerical inversion method on each sample, as in this case, the number of multiple solutions is limited. The true (n,k) is deduced by confronting multiple solutions obtained on both samples. For thicker layers, we have developed a new inversion scheme that uses simultaneously the measurements performed at different thicknesses. This approach makes easier the determination of true (n,k) value from multiple solutions than the previous one. Figure 1 shows an example of extracted (n,k) obtained on P3HT deposited by spin coating on a glass substrate, compared to data found in the literature for similar material.

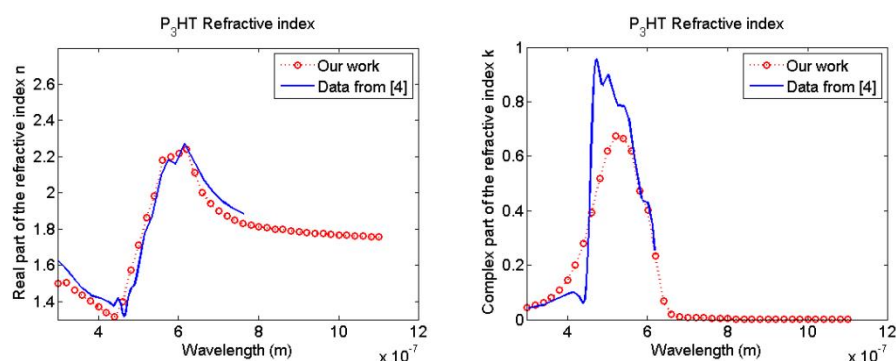


Figure 1 Real refractive index n (left image) and complex refractive index k (right) of P3HT samples

This work has been supported by the FUI Minalogic project ROXTAR.

### References

- [1] C. J. Brabec, *Organic photovoltaics: concepts and realization*, Springer Science & Business Media (2003)
- [2] Herzinger, C. M., Johs, B., McGahan, et al., *Journal of Applied Physics*, 83(6), 3323-3336 (1998)
- [3] D. Poelman, P. F. Smet, *Journal of Physics D: Applied Physics*, 36(15), 1850 (2003)
- [4] F. Monestier, Doctoral dissertation, Université Paul Cézanne-Aix-Marseille III (2008).
- [5] J. C. Manifacier, J. Gasiot, J.P. Fillard, *Journal of Physics E: Scientific Instruments*, 9(11), 1002 (1976)
- [6] A. B. Djurizi, T. Fritz, K. Leo, *Optics communications*, 183(1), 123-132 (2000)
- [7] R. E. Denton, R. D. Campbell, S. G. Tomlin, *Journal of Physics D: Applied Physics*, 5(4), 852 (1972)