Investigating Substrate Effect on the Optical Properties of Thick Polymers by Spectroscopic Ellipsometry

Malika Khettab[1,2], Armelle Girard[3], Jorge Linares[2,4], Philippe Pougnet[5], Pierre Richard Dahoo[2,6]

1. *Laboratoire d'Ingénierie des Systèmes de Versailles, Université de Versailles Saint-Quentin-en-Yvelines, 10-12, Avenue de l'Europe, 78140 Velizy, France*
2. *Chair Materials Simulation and Engineering, UVSQ, Université Paris Saclay, 11 Boulevard d'Alembert, F-78280, Guyancourt, France*
3. *Laboratoire d'étude des microstructures, ONERA-CNRS (UMR 104) 29 avenue de la division Leclerc, 92322 Châtillon, France*
4. *GEMaC, CNRS-UMR 8635, Université de Versailles St. Quentin en Yvelines, 45 avenue des Etats-Unis, 78035 Versailles, France*
5. *Valéo, 2 rue André Boulle, F-94046, Créteil Cedex, France*
6. *LATMOS, Université de Versailles-Saint-Quentin-en-Yvelines, Sorbonne Universités, CNRS-UMR 8190, Université Paris Saclay, 11 Boulevard d'Alembert, F-78280, Guyancourt, France*

Polymer based materials are used for encapsulation of interconnections and device packages in power mechatronics modules. Different substrate-polymer material interfaces are encountered in the module namely silicon for the active element, copper for busbar and wires and aluminum for the cooling element [1]. The present work concerns the use of spectroscopic ellipsometry to study the effect of different substrates on the optical properties of several polymers [2]. Thin films were prepared from the polymer reactants (mono-component (M) and bi-component (B) silicone gels or epoxy E) by spin coating technique on Al, CuNi, Si and quartz substrates. A M-2000V spectroscopic ellipsometer from J.A. Woollam was used to characterize the samples in the 370 nm to 1000 nm range just after preparation and after they were heated in a humid atmosphere. Analysis was performed using the complete EASE software of Woollam. The dielectric function, thickness and roughness values of the polymer on the substrate are determined with the "B-Spline model" as a function of the wavelength. The thickness is then fixed until the simulations reproduce the oscillations present in the spectra. The B-Spline model is then replaced by the Cauchy model to determine the optical properties. Results are given for seven samples of silicone gels and epoxy resin (B1, B2, B3, B4 for the bi-component, M1, M2, M3 for the mono-component and E1for the epoxy resin). Figure 1 gives an example of the fit for M1 on quartz substrate and the corresponding optical constants in the UV-NIR range.

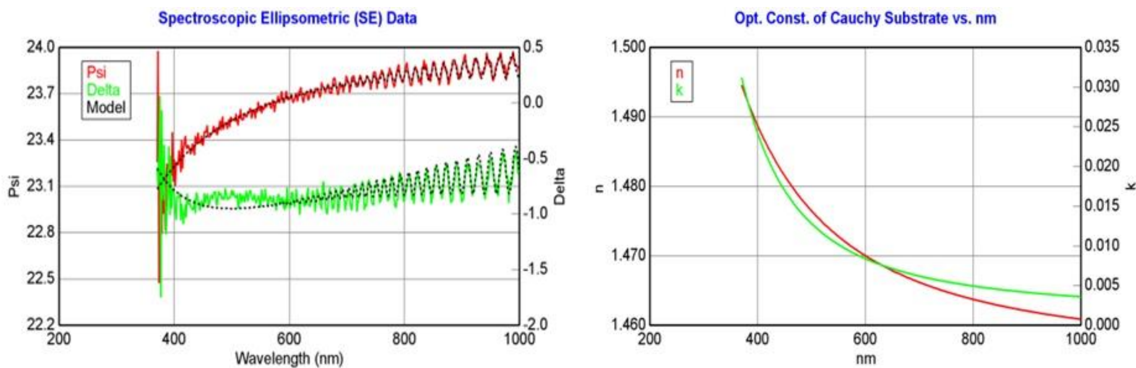

Fig. 1 Fit for M1 on quartz substrate and the corresponding optical constants.

The thickness were measured to be between 15 and 25 µm. The values of n are between 1.45 and 1.48 for B1, B2, B3, B4 and M1, between 1.36 and 1.38 for M2, between 1.38 and 1.44 and M3 and remains around 1.5 for the epoxy resin. With regard to k, the values are very low, below 10^{-2} (B1: 10^{-2}; B2: 10^{-4} to 2.5 10^{-2}; B3: 10^{-4} to 3 10^{-3}; B4: 10 $^{-4}$ to 8 10^{-3}, M1: 5 10^{-3} to 3 10^{-2}; M2: 10^{-3} to 6 10^{-2}; M3: 10^{-2} to 7 10^{-2}; E1: 10^{-2} to 5 10^{-2}); The band gap was determined from a plot of the absorption coefficient as a function of the photon energy. It is 3.0 ev with the quartz substrate and 3.17 ev with Al substrate for B1.

References

[1] Pierre Richard Dahoo, Malika Khettab, Jorge Linares, Philippe Pougnet, *Non-Destructive Characterization by Spectroscopic Ellipsometry of Interfaces in Mechatronic Devices*, *Embedded Mechatronic Systems 1. Analysis of Failures, Predictive Reliability*, Editors Abdelkhalak El Hami et Philippe Pougnet, Elsevier, **Chapter 2**, , 978-1-78548-013-3, (2015)

[2] Malika Khettab, *Study of the influence of the potting at IML (Insulated Metal Leadframe), in packaging mechatronics power switch module*, Phd Dissertation, University of Versailles St Quentin, (2014)