



**John Edicson Hernández Sánchez**

**Assembly of a surface plasmon resonance (SPR)  
spectrometer for the characterization of thin organic films**

**Dissertação de Mestrado**

Thesis presented to the Programa de Pós-Graduação em Física of the Departamento de Física do Centro Técnico Científico da PUC-Rio, as partial fulfillment of the requirements for the degree of Mestre.

Advisor : Prof. Tommaso Del Rosso  
Co-Advisor : Prof. Omar Pandoli

Rio de Janeiro  
December 2013



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John Hernández Sánchez graduated from the Universidad Nacional de Colombia in Physics, working in High Energy Physics. He then obtained a Master degree at the PUC-Rio, where he specialized in Surface Plasmon Resonance (SPR) under the orientation of Professor Tommaso Del Rosso.

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*A Isa, mi amor más tierno  
A Lili, a tu linda sonrisa, mi amor bello!!  
A los pilares de mi vida: El negro,  
la negra y Lisa por la larga travesía  
y compañía a través de estos años  
y a TI por enseñarme que en la vida todo suma.*

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## Abstract

Hernández, John; Del Rosso, Tommaso; Pandoli, Omar. **Assembly of a Surface Plasmon Resonance (SPR) Spectrometer for the characterization of thin organic films**. Rio de Janeiro, 2013. 79p. Dissertação de Mestrado — Departamento de Física , Pontifícia Universidade Católica do Rio de Janeiro.

Surface Plasmon Resonance Spectroscopy (SPR) is an optical technique widely used to monitor the physical or chemical changes occurring at a metal-dielectric interface. The simultaneous measurement of the thickness and the index of refraction of organic thin films adsorbed or deposited on the metal flat surface require two independent measurements following a methodology commonly named in literature as Two-Colors Method or Two-Medium Method. In the first one, the two measurements are performed using different wavelength of the electromagnetic radiation interacting with the sample. In the second one the index of refraction of the external medium (gas, liquid) is changed between the two measurements. While the first method implies the knowledge of the dispersion function of the organic layer, the second one gives accurate results only when the organic molecules don't interact chemically with the external fluid. Both of these methods present difficulties when applied to the characterization of luminescent organic materials, most of the time highly reactive to humidity and to the contact with organic solvents. In this work an automated SPR spectrometer was assembled and first tested on the characterization of home-made samples in terms of the absolute value and homogeneity of the optical constants of the metal deposition supporting the plasma wave. We demonstrate that accurate measurements of such optical constants allow the determination of the index of refraction of thermally evaporated luminescent organic thin films using a Two-Metal Substrate Method. This method, to our knowledge only theorized up to now in literature, has been applied to an encapsulated sample containing a thin film of commercial Alq3. Further, the degradation of the metal/Alq3 interface exposed to air has been real time monitored indicating a progressive drop in the angle of resonance of the sample.

## Keywords

Optical Sensors; Surface Plasmon Sensors (SPP); Metal Organic Interfaces; Thin Films; index of refraction; Nondestructive Testing.

## Resumo

Hernández, John; Del Rosso, Tommaso; Pandoli, Omar. **Montagem de um Espectrômetro SPR para a caracterização de filmes finos orgânicos**. Rio de Janeiro, 2013. 79p. Dissertação de Mestrado — Departamento de Física, Pontifícia Universidade Católica do Rio de Janeiro.

Espectroscopia de ressonância plasmônica de superfície (SPR) é uma técnica óptica amplamente utilizada para monitorizar as alterações físicas ou químicas que ocorrem em uma interface metal - dielétrico. A medição simultânea da espessura e do índice de refração de filmes finos orgânicos, adsorvidos ou depositados sobre a superfície plana de um metal, requer duas medições independentes seguindo uma metodologia designada na literatura como método de duas cores ou método de dois meios. Na primeira, as duas medições são realizadas utilizando diferentes comprimentos de onda da radiação eletromagnética interagindo com a amostra. Na segunda, o índice de refração do meio externo (gás, líquido) é alterado entre as duas medições. Enquanto o primeiro método implica no conhecimento da função de dispersão da fase orgânica, o segundo só produz resultados precisos quando as moléculas orgânicas não interagem quimicamente com o fluido externo. Ambos os métodos apresentam dificuldades quando são aplicados à caracterização de materiais luminescentes orgânicos, os quais são na maior parte do tempo altamente reativos à umidade e ao contato com solventes orgânicos. Neste trabalho foi montado um espectrômetro de SPR automatizado. Primeiramente, ele foi testado na caracterização de amostras feitas no laboratório em termos do valor absoluto, e da homogeneidade das constantes ópticas da deposição metálica que suporta a onda de plasma. Nós demonstramos que medições precisas de constantes ópticas permitem a determinação do índice de refração de filmes finos orgânicos luminescentes, evaporados termicamente utilizando o método de substrato com dois metais. Este método, que até onde sabemos é apenas teorizado na literatura, foi aplicado a uma amostra encapsulada com um filme fino de  $Alq_3$  comercial. Além disso, a interface metal/ $Alq_3$  foi exposta a ar, e a degradação foi monitorada em tempo real, indicando uma diminuição progressiva do ângulo de ressonância da amostra.

## Palavras-chave

Sensores óticos; Polaritones Superficiais Plasmônicos (SPP); Interfaces Metal-Orgânico; Filmes Finos; Índice de refração; Controles não destrutivos;

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*hominum mens numquam fingere sibi valuisset:  
Aeternum ingreditur tempus, Quod est Omne  
absconditur in parte, Deus hominis suscipit  
vultum. –... definitiva que la mente humana,  
partiendo de sí misma, ni tan siquiera hubiera  
podido imaginar: el Eterno entra en el tiempo,  
el Todo se esconde en la parte y Dios asume el  
rostro del hombre.*

**Juan Pablo II, *Fides et Ratio*.**