Centro di Eccellenza “NIS”
Università di Torino

Dipartimento di Fisica
Università di Torino

Sezione di Torino
Istituto Nazionale di Fisica Nucleare

“Spectroscopic Ellipsometry” Workshop

Tutorials on fundamental principles and experimental procedures of the technique
Practical demonstration session with state-of-the-art instrumentation at NIS
Case studies of ellipsometric characterization of advanced materials and devices

Tuesday 16 October 2012
Aula 21, Centro di Eccellenza “NIS”
Via G. Quarello 11, Torino

Program

Time	Topic	Speaker
9^{00} - 9^{10}	Introduction	P. Olivero, *UniTo - NIS*
9^{10} - 9^{50}	Theory and Fundamental of Spectroscopic Ellipsometry	S. Schutzmann, *L.O.T. Oriel Italia*
10^{00} - 11^{00}	Spectroscopic Ellipsometry: Measurement Strategies and Instrumentations	S. Schutzmann, *L.O.T. Oriel Italia*
11^{00} - 11^{30}	*Coffee break*	
11^{30} - 12^{10}	Data Analysis in Spectroscopic Ellipsometry	A. Sytchkova, *ENEA Casaccia*
12^{20} - 13^{00}	Spectroscopic Ellipsometry: Two Examples of Recent Research	A. Sytchkova, *ENEA Casaccia*
13^{00} - 14^{30}	*Lunch break*	
14^{30} - 15^{00}	Optical constants and photocatalytic activity of sol gel TiO_2 thin films	V. Maurino, *UniTo - NIS*
15^{00} - 15^{30}	Ellipsometric characterization of LCD displays and solar mirrors	G. Ricchiardi, *UniTo - NIS*
15^{30} - 16^{00}	Interface plasmonic properties of silver coated by ultrathin metal oxides	M. Giambra, *ENEA Casaccia*
16^{00} - 16^{30}	*Coffee break*	
16^{30} - 17^{00}	Spectral ellipsometry analysis of thin dielectric film for optical application	L. Lolli, *INRiM*
17^{00} - 17^{30}	Refractive index variation of ion-implanted diamond	F. Bosia, *UniTo - NIS*
17^{30} - 17^{40}	Closing remarks	TBA, *UniTo - NIS*

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Theory and Fundamental of Spectroscopic Ellipsometry

Stefano Schutzmann

L.O.T. Oriel Italia

In this presentation, an overview of the theory and physics behind Spectroscopic Ellipsometry (SE) is given. Principles of Optics which are strictly related with SE (e.g. polarization of light, reflections and transmission, Fresnel coefficients, etc..) as well as fundamentals of light-matter interaction (Optical Constants, Dielectric Function, Kramers-Kroenig relations, etc..) are discussed.

Particular attention is given to the understanding of SE's fundamental equation and the two main measured values, Ψ and Δ.

Finally, an overview of the data analysis procedure is presented.

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Spectroscopic Ellipsometry: Measurement Strategies and Instrumentations

Stefano Schutzmann

L.O.T. Oriel Italia

This talk covers two distinct aspects of any Spectroscopic Ellipsometry (SE) experiment.

In the first part, the application-dependent experimental strategies are discussed together with their effect on the measured Ψ and Δ values. An overview of some of the advanced measurement types (Depolarization, Non-Idealities, Mueller Matrix) is presented, as well.

In the second part of the talk, an outline of the experimental configurations used on the modern SE instrumentations is given. Application of SE for in-situ and real-time monitoring, as well as for industrial purposes is briefly discussed.

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Data Analysis in Spectroscopic Ellipsometry

Anna Sytchkova

Optical Coatings Laboratory, ENEA Casaccia

In this talk, an overview of the data analysis procedure is presented. More generally, we start from general properties of spectral curves starting from reflectance/transmittance measurement passing then to ellipsometry. Examples of exhaustive characterization of thin films using spectroscopic techniques are given, both of single layer and multilayer coatings. The comparative approach allows better understanding of methodology in coating characterization, when taking advantage from specificity of each measurement technique.

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Spectroscopic Ellipsometry: Two Examples of Recent Research

Anna Sytchkova

Optical Coatings Laboratory, ENEA Casaccia

This presentation we show two examples of recent research on advanced transparent conductors:

- Conductivity profiling of TCO ultrathin layers;

- Characterization of metal-dielectric electrodes.

Employment of variable angle spectroscopic ellipsometry is underlined.

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Optical constants and photocatalytic activity of sol gel TiO_2 thin films

Valter Maurino, Claudio Minero, Marco Minella

"NIS Centre of Excellence" and Chemistry Department, University of Torino

High activity supported TiO_2 films are needed in order to exploit their photocatalytic properties for pollutant removal, energy conversion and for the synthesis of smart materials with self cleaning and self sterilizing properties. Fundamental limitation to a widespread use of photoeffects at TiO_2 films is the low photonic efficiency. Crucial issues are the efficiency in photogenerated charge carriers separation, the rate of interfacial charge transfer reactions, and the low absorption in the visible spectrum. A proper gradient of electronic properties at length scales of nanometers can enhance the charge separation, improving the photonic efficiency. A gradient in the n doping of TiO_2 can be introduced by tuning oxygen vacancies through thermal treatment of nanometers thick TiO_2 films in oxidant atmospheres. Another approach can be the introduction of aliovalent cations in the TiO_2 lattice.

In this work the optical constants (n and k) of sol-gel derived TiO_2 thin films were characterized by spectroscopic ellipsometry. Most films are characterized by a vertical gradient of optical properties and porosity, and in particular of the refraction index in the visible region, in the first 10-20 nanometers. This vertical gradient is tuned by introducing surfactants and/or aliovalent cations with ionic radius compatible with Ti(IV). The correlation between optical constants, precursor sol compositions and photocatalytic activities of the films will be discussed.

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Ellipsometric characterization of LCD displays and solar mirrors

Gabriele Ricchiardi

"NIS Centre of Excellence" and Chemistry Department, University of Torino

- to be announced -

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Interface plasmonic properties of silver coated by ultrathin metal oxides

Marco Angelo Giambra, Danilo Zola, Maria Luisa Grilli, Ming Fang, Anna Sytchkova

Optical Coatings Laboratory, ENEA Casaccia

Many fields of high technology take advantage of conductor-dielectric interface properties. Deeper knowledge of physical processes that determine the optical response of the structures containing metal-dielectric interfaces is important for improving the performance of thin film devices containing such materials. Here we present a study on optical properties of two ultrathin metal oxides deposited over thin silver layers. Two widely used materials, alumina and silica, were selected for deposition by r.f. sputtering, and the created metal-dielectric structures were investigated in this work using attenuated total reflectance (ATR) technique and by variable-angle spectroscopic ellipsometry (VASE). VASE was performed with a help of a commercial ellipsometer at various incident angles and in a wide spectral range. A home-made sample holder manufactured for WVASE ellipsometer and operational in Otto configuration has been implemented for angle-resolved and spectral ATR measurements. Simultaneous analysis of data obtained by these two independent techniques allows elaboration of a representative model for plasmonic-related phenomena at metal-dielectric interface. The optical constants of the interface layers formed between metal and ultrathin oxide layers are investigated. A series of oxides chosen for this study allows a comparative analysis aimed for selection of the most appropriate materials for different applications.

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Spectral ellipsometry analysis of thin dielectric film for optical application

Lapo Lolli, Emanuele Taralli, Mauro Rajteri, Giorgio Brida

Istituto Nazionale di Ricerca Metrologica

Spectroscopic ellipsometry is a powerful versatile and non-invasive measurement technique to investigate optical material. Recently it has been applied at INRIM to investigate two different prototype detectors.

By using a VASE Woollam instrument, both the oxide thicknesses and uniformity of predictable quantum efficient detectors (PQED) has been studied. PQED are based on p-type silicon photodiodes with a natural inversion layer forming a np junction. They are developed to operate inside of cryogenic radiometers as the primary detector standards for the absolute measurement of the radiant power. The crucial point for the predictable behavior of these detectors is uniformity and optical properties of the oxide layer.

The second prototype is the superconducting Transition-Edge Sensor (TES): a photon number resolving (PNR) detector developed at INRIM to operate in the visible and near infrared spectral range. This detector is a bilayer based on titanium and gold thin film. Since its PNR property, TES results one of the most promising candidate for quantum application information and quantum metrology application. To improve the quantum efficiency of this device, which is limited by the natural reflectivity of the metal layer, the optical constants of the thin films have been determinate by ellipsometric measurements.

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Variation of refractive index in diamond upon ion implantation

Federico Bosia, Alfio Battiato, Simone Ferrari, Paolo Olivero, Anna Sytchkova, Ettore Vittone

"NIS Centre of Excellence" and Physics Department, University of Torino

We discuss recent measurements using variable-angle spectroscopic ellipsometry to evaluate the variation of the refractive index of ion implanted single-crystal diamond. Both electronic and nuclear damage regimes are investigated by considering different ions and energies for the implantations. An increase is found in the real part of the refractive index for all considered fluences. The index depth variation correlates well with the calculated vacancy density in the nuclear damage regime and with electronic energy loss in the electronic damage regime. X-ray diffraction measurements to determine strain levels indicate that the refractive index variation does not depend on stress effects, but probably on modification of the polarizability. We show that a considerable increase of the index can be obtained and that annealing can help reduce optical absorption, thus offering new microfabrication possibilities for waveguides and other photonic structures in diamond.

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