VÁCUO 2019

Workshop

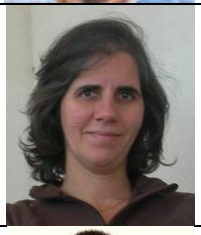
February 26, 2019

Universidade NOVA de Lisboa

The VACUO 2019 Workshop aims to bring together national and international experts in a more intimate meeting that promotes discussion on deposition, materials synthesis and characterization techniques using vacuum technologies. The 2019 edition will be held on Tuesday February 26, between 2-6 pm, at Universidade NOVA de Lisboa (Campus da Caparica, anfiteatro Manuel Laranjeira), organized by CeFITeC, Centro de Física e Investigação Tecnológica, in collaboration with the Sociedade Portuguesa de Vácuo - SOPORVAC. The topics of the Workshop will focus on vacuum technology and applications, functional coatings for the industry and fundamental research, with applications in the field of plasmonics, spintronics, electronics, solar and nanostructured surfaces.

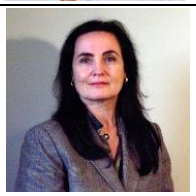
Program:

13:55–14:00 **Foreword:** Orlando Teodoro, CEFITEC, Nova University of Lisbon

	14:00-14:20 **Ferroelectric-dielectric structures for energy storage capacitors** José Pedro Silva Centre of Physics, University of Minho, Braga
	14:20–14:40 **Semiconductor thin films by Hybrid Pulsed Laser Deposition methods** Reinhard Schwarz Departamento de Física, Instituto Superior Técnico, Lisboa
	14:40-15:00 **Ultrathin films for spintronic applications** Susana Cardoso de Freitas, INESC Microsystems & Nanotechnologies Lisbon
	15:00-15:20 **Nanostructured thin films with Au nanoparticles for plasmonic sensing** Marco Rodrigues Centre of Physics, University of Minho, Guimarães

	15:20-15:40 **Simulação de um manómetro de ionização Bayard-Alpert em SIMION** Ricardo Silva CeFITeC, Universidade NOVA de Lisboa
	15:40-16:00 **Parylene-C based conformable electronics** Joana Pinto i3N/CENIMAT, Universidade NOVA de Lisboa

COFFEE BREAK
16:00-16:20

	16:20-16:40 **Nanocomposite coatings exhibiting Localized Surface Plasmon Resonance obtained by sputtering techniques** Nuno Figueiredo SEG-CEMMPRE, Department of Mechanical Engineering, University of Coimbra
	16:40-17:00 **ZnO-based thin films for thermoelectric applications** Filipe Correia Centre of Physics, University of Minho, Guimarães
	17:00-17:20 **Nanostructured surfaces and atomically sharp interfaces. Applications in energy and nanoelectronics** CeFITeC, Universidade NOVA de Lisboa
	17:20-17:40 **X-ray photoelectron spectroscopy at i3N/CENIMAT** Jonas Deuermeier i3N/CENIMAT, Universidade NOVA de Lisboa

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WORKSHOP VÁCUO 2019 ABSTRACTS

Ferroelectric-dielectric structures for energy storage capacitors

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Abstract:

Recently, there is a great demand for high energy storage and conversion devices to meet the exponential growth of power requirement in the modern society [1,2]. Among the various available electrical energy storage devices, such as batteries, supercapacitors and dielectric capacitors, the dielectric capacitors exhibit unique advantages such as ultrafast charge-discharge speed and high energy storage density [3,4]. Moreover, among them, the ferroelectric film capacitors usually possess short charge-discharge time (in the ns range), that make them suitable candidates for fast energy storage applications [5]. In the present work, the effect of the insertion of a thin dielectric HfO2:Al2O3 (HAO) layer at different positions in the Pt/0.5Ba(Zr0.2Ti0.8)O3-0.5(Ba0.7Ca0.3)TiO3 (BCZT)/Au structure on the energy storage performance of the capacitors has been investigated. A high storage performance is achieved through the insertion of a HAO layer between BCZT and Au layers. The insertion of the dielectric layer causes a depolarization field which results in a high linearity hysteresis loop with low energy dissipation. The Pt/BCZT/HAO/Au capacitors show an impressive energy storage density of 99.8 J/cm3 and efficiency of 71.0%, at an applied electric field of 750 kV/cm. By combining ferroelectrics and dielectrics into one single structure, the proposed strategy provides an efficient way for developing high efficient energy storage capacitors.

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Semiconductor Thin Films by Hybrid Pulsed Laser Deposition Methods

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Abstract:
Pulsed Laser Deposition, PLD, is a flexible and low-cost thin film deposition method, widely used for the preparation of insulating, semiconducting and metallic thin films with thickness ranging from a few nanometers up to tens of microns. In the present contribution we will describe our work during the past years at IST, Lisbon. Straight-forward PLD was combined in some cases where inert background gas is present, or with simultaneous addition of a plasma-enhanced chemical vapour deposition, CVD, of oxygen or nitrogen gas. In special cases we employed a cyclic hybrid process. Nanostructures like nanospheres and nanowires have been studied. The films were characterized by different structural and optical methods including X-ray diffraction, atomic force microscopy (AFM), dark and photoconductivity, steady-state and time-resolved photoluminescence (PL), optical transmission spectroscopy and time resolved microwave conductivity (TMWC). Surface morphology and chemical composition was analysed with X-ray Photoelectron Spectroscopy (XPS). We will describe our experience and the advantages of PLD deposition of (a) semiconductors like microcrystalline Si, diamond-like carbon (DLC), GaN, ZnN, ZnO and (b) insulators like SiOx and ferroelectric sodium-potassium-niobate (NKN).

Ultrathin films for spintronic applications

Susana Cardoso, Ana Neves Silva, Diana Leitão, Rafael Santos, Marília Silva, Paulo P. Freitas
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Abstract:
Ion Beam Assisted Deposition has been used to produce thin films for spintronics. In particular, ultrathin films based on oxides (MgO and AlOx) have been of particular interest for industrial products as magnetic sensors and magnetic memories (MRAM). Here, we will describe methodologies to grow oxide films thinner than 2nm, using Nordiko machines, compatible with 200mm diameter wafers, in batch production architectures. In particular, MgO deposition conditions are studied over a wide range of operating conditions, using the assist beam either with large power (concurrent etching regime) or low power (soft energy transfer regime). XRD spectra of Glass/MgO films show that MgO deposited without the assistance source is always amorphous, and the use of an assist beam has strong impact on the crystallization of both MgO and adjacent CoFeB films. These thin films are integrated with thin magnetic layers (NiFe, CoFeB, Ru, among others) and microfabricated as functional devices. The impact on the plasma composition and ion energy on the thin film properties is addressed, for several key applications.

Nanostructured thin films with Au nanoparticles for plasmonic sensing

Marco S. Rodrigues, Joel Borges, Filipe Vaz
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Abstract:
Noble metal nanoparticles have been deeply investigated due to their unique optical properties related to the Localized Surface Plasmon Resonance (LSPR) phenomenon. The nanoparticles' optical response can be tailored by changing their morphological and geometric characteristics (size, shape and distribution) and dielectric function of the surrounding host matrix. When these nanoparticles are embedded in a porous host matrix, e.g. produced using a GLancing Angle Deposition (GLAD) system, analyte molecules can easily diffuse to the vicinity of the nanoparticles and induce subtle changes in the refractive index. These interactions can be detected in transmittance spectra by monitoring the shape of the LSPR extinction band (T-LSPR). Therefore, several transduction mechanisms can be used to build T-LSPR sensors. This work combines (i) the preparation of nanostructured plasmonic thin films, (ii) sensitivity studies and (iii) LSPR extinction band processing. An environmentally friendly physical deposition method (reactive magnetron sputtering), with a GLAD system was used, allowing the preparation of plasmonic thin films with tailored porosity. Refractive index sensitivity studies were conducted in a controlled atmosphere chamber with real-time T-LSPR monitoring. The obtained signals were then processed using an algorithm that analyses changes in several parameters of the LSPR extinction band. The results showed that the refractive index sensitivity of the films is improved for higher porosities, thus confirming the possibility of using these nanostructured plasmonic thin films as T-LSPR sensors.

Simulação de um manómetro de ionização Bayard-Alpert em SIMION

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Abstract:
Os manómetros de ionização são os únicos com a capacidade de efetuar medições em alto e ultra-alto vácuo, sendo de extrema relevância em investigação e na indústria. Contudo, estes medidores são pouco robustos e apresentam uma elevada deriva de medição a longo prazo. A estratégia para a melhoria destas limitações passa pela compreensão de todos os detalhes do seu funcionamento. Simulações detalhadas não só proporcionam descobrir as fontes de instabilidade dos manómetros existentes como dimensionar novos medidores mais confiáveis.
Neste trabalho é apresentada a simulação numérica de um manómetro de ionização Bayard-Alpert através do software SIMION 8.1. A sensibilidade do medidor, sendo o parâmetro mais relevante de um manómetro de ionização, foi calculada através de duas aproximações distintas. Na primeira, o SIMION foi utilizado na determinação do livre percurso médio das trajetórias dos eletrões e da eficiência de coleção de iões. Através destes valores, e conhecendo a secção eficaz de ionização e a temperatura do gás, a sensibilidade pode ser facilmente calculada.
Na segunda, foi implementado o método de Monte Carlo em código Lua para simular a ionização do gás por impacto eletrónico. O código Lua é incorporado na simulação das trajetórias em SIMION. Esta aproximação avalia a contribuição de cada trajetória para a ionização do gás. Além disso, é considerada a energia dos eletrões no cálculo da probabilidade de ionização, e, pela primeira vez, é contabilizada a contribuição da retrodispersão de eletrões na rede do manómetro, para a sensibilidade. As aproximações simuladas foram testadas com a mesma geometria de um manómetro que foi simulado por um grupo do CERN. Quantitativamente, os resultados obtidos por ambas as aproximações revelaram-se em concordância com as simulações do CERN. Considerando uma rede de molibdénio, as simulações de Monte Carlo indicaram uma contribuição relativa dos eletrões retrodispersos de 14%, para a sensibilidade.

Parylene-C based conformable electronics

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Abstract:

The implementation of electronic devices in flexible substrates has shown remarkable breakthroughs enabling the fabrication of different types of devices such as sensors, flexible solar cells or batteries, that are suitable to be applied in wearable electronics. In order to be used in flexible substrates, devices should present high mechanical stability and be produced at relatively low temperatures while insuring high performances. The combination of organic layers, that are usually mechanically robust, with inorganic oxides that can be produced at low temperatures allows the development of devices with simultaneously high mobilities and flexible properties. Parylene C reveals itself as a promising material due to the excellent thermal, mechanical, chemical and electrical insulating properties. It is a CVD biocompatible polymer that polymerises at room temperature producing a conformal and pinhole-free layer. We present a set of conformable devices exploring the use of Parylene C in its multiple roles: as a ultrathin substrate, as a dielectric layer and as an encapsulation/passivation material. Different types of devices will be presented such as TFTs, capacitors and temperature sensors. All devices were patterned by common lithographic techniques (photolithography or/and shadow masks) in a clean room environment and using magnetron sputtering and electron beam evaporation for the fabrication of the semiconductor and electrical contacts respectively. The mechanical and electrical response of the devices will be discussed, as well as the role of Parylene passivation layer that represents an additional advantage due to the excellent moisture barrier properties of this material. These results clearly show that these hybrid devices are excellent candidates for flexible electronics, where high mobilities are insured by the inorganic active layers and the conformability, flexibility and electric isolation is insured by the organic dielectric. The use of Parylene as an ultrathin substrate is also discussed allowing for the fabrication of highly conformal devices that can be applied in wearables electronics.

Nanocomposite coatings exhibiting Localized Surface Plasmon Resonance obtained by sputtering techniques

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Abstract:
Nanocomposite coatings containing metal nanoparticles have received increasing interest in the last decades from both researchers and industry. One of the main properties of interest of the metal nanoparticles is their ability to support Localized Surface Plasmon Resonances (LSPRs), optically induced oscillations of free electrons at the surface of metal nanoparticles. The excitation of LSPRs by incoming light results in strong light extinction effects that are heavily dependent on the nanoparticle's dielectric constant, size, shape and concentration and also on the dielectric constant of the surrounding medium. For each coating application it is required a particular LSPR signal from the nanocomposite, making mandatory the use of deposition methods that allows good control over the nanoparticle's morphology, concentration and distribution in the matrix.
In this work, Au nanoparticles were incorporated into different matrixes (Al2O3, WO3, TiO2 and AlN) using three different sputtering techniques: (i) co-sputtering followed by thermal annealing treatments; (ii) alternating-sputtering using pulsed DC power sources and (iii) alternating-sputtering using a plasma gas condensation (PGC) nanoparticle source. The design of the coatings was carefully optimized according to the application in view, hard decorative coatings or gas sensors.
The first method allowed the deposition of nanocomposites with a relatively homogeneous dispersion of spherical Au nanoparticles within the matrixes (with sizes up to 8 nm). The second method allowed a more effective and independent control over the nanoparticles morphologies without the need of thermal annealing treatments (spherical and spheroidal nanoparticles with sizes up to 15 nm were incorporated in the matrixes). The third method allowed the production of large amounts of nanoparticles with high level of control over its mean size (spherical nanoparticles with sizes between 5-65 nm were deposited with varying deposition rates and size dispersions). The functional properties of the coatings were studied and related with their structure and microstructure.

ZnO-based thin films for thermoelectric applications

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Abstract:

Zinc oxide has drawn attention to numerous fields of research as a transparent conductive oxide (TCO). ZnO's tuneable electrical conductivity, along with its high transparency, enables its use in applications ranging from buffer layers of solar cells to thin-film transistors [1,2]. It is expected that by doping ZnO thin films with Group IIIB elements, such as Ga and Al, will improve its electrical conductivity [3]. The goal is to achieve both a high ZT thermoelectric figure of merit and a high power factor, resulting from the optimisation of chemical modulation and electrical conductivity combined with a decrease in thermal conductivity. In this work, ZnO:Ga,Bi and ZnO:Al,Bi thin films were produced by d. c. magnetron sputtering in the confocal geometry and were characterized concerning their thermoelectric, electrical, optical and morphological features, which are influenced by the deposition parameters and dopant conditions [4,5].

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Nanostructured surfaces and atomically sharp interfaces. Applications in energy and nanoelectronics

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Abstract:
The presentation covers two main topics nanostructured surfaces and atomic sharp interfaces: growth and characterization. The thinnest possible uniform and stable oxide layer grown thermally on Si (111) is 0.8 nm thick. This oxide is grown in a self-limiting process, which has been fully characterized high-resolution core level photoemission at the ASTRID storage ring facility at Aarhus, Denmark. To study the tunneling properties of this oxide covering the Si (111) surface isolated nanometer-sized Sn islands in different diameters and concentrations were deposited and became negatively charged, with different charges depending on their size.Nanodevices fabricated from SiC/Si epitaxial wafers has shown to need surface passivation and insulating coatings which depends on the future applications, in order to provide electrical stability, to reduce reverse-current leakage and to increase breakdown voltage. New semiconductor materials such as SiC and GaN it is expected to provide in the future large efficiency gains in energy conversion in diverse applications and high power nanoelectronics. A critical issue for developing metal–oxide–semiconductor field effect transistor devices of SiC is the choice of dielectric materials for passivation, which depends on the future applications. This system has a number of problems related to the higher band gap of SiC, which energetically favours more interface states than for SiO2 on Si, and the low dielectric constant of SiO2 leading to 2.5 higher electric fields across the oxide than in the surface of SiC, and to a premature breakdown at the higher fields and higher temperatures that SiC devices are designed to operate under. The aim of the present study is to investigate an easy and reproducible method for depositing a thin (1–2nm) film of amorphous Al2O3 with an atomically sharp Al2O3/SiC interface on the surface of 3C-SiC on Si. The processes and the resulting structures of the layers and the interface were monitored, in-situ, using synchrotron radiation induced core level photoemission spectroscopy at ASTRID, Aarhus, Denmark.

Acknowledgements:
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X-ray photoelectron spectroscopy at i3N/CENIMAT

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Abstract:
The capabilities and limitations of X-ray and UV photoelectron spectroscopy as a surface analysis technique operating under UHV conditions are reviewed. Both conceptual and practical aspects are considered. The characteristics of the equipment installed at i3N/CENIMAT are presented, which features a state-of-the-art gas cluster gun for advanced depth profiling.