K 7: Internal Symposium Optic Coatings and Plasma Technology

Time: Thursday 10:30–13:00 Location: MB HS

Invited Talk K 7.1 Thu 10:30 MB HS

A global model for radio frequency magnetron sputtering processes — •Dennis Engel, Laura Kroll, and Ralf Peter Brinkmann — Institute of Theoretical Electrical Engineering, Ruhr University Bochum, Germany

Magnetron sputtering is an established technology to deposit thin films on large substrates. Employing RF power (instead of the conventional DC power) allows to sputter not only electrically conductive materials but also dielectrics like optical coatings. This contribution presents a global model for such an RF driven magnetron which is an extension of a previously published lumped circuit description of unmagnetized RF discharges [1]. As its predecessor, the model represents the discharge by separate bulk and sheath zones which communicate via Kirchhoff relations. The extension accounts for the presence of a magnetized region with reduced electric conductivity [2,3]. The model evaluates quickly and may be used for the purpose of model based control.

Invited Talk K 7.2 Thu 11:00 MB HS

The Multipole Resonance Probe as a powerful diagnostic tool for industrial plasma processes — •Moritz Oberberg[1], Stefan Ries[1], Christian Wölfel[2], Jens Harhausen[3], Dennis Pohle[4], Christian Schulz[4], Oliver Schmidt[5], Wladislaw Dobrygin[5], Ilona Rolfes[4], Ralf Peter Brinkmann[6], and Peter Awakowicz[1] — [1]Lehrstuhl für Allgemeine Elektrotechnik und Plasmatechnik, Ruhr-Universität Bochum — [2]Lehrstuhl für Automatisierungstechnik und Prozessinformatik, Ruhr-Universität Bochum — [3]Leibniz Institut für Plasmaforschung und Technologie, INP Greifswald — [4]Lehrstuhl für Hochfrequenzsysteme, Ruhr-Universität Bochum — [5]Robert Bosch GmbH — [6]Lehrstuhl für Theoretische Elektrotechnik, Ruhr-Universität Bochum

Based on the concept of active plasma resonance spectroscopy (APRS) the Multipole Resonance Probe (MRP) has been introduced as a diagnostic tool for electron density measurements. In recent years efforts in modeling, simulation, and experiments lead to advances in understanding and design of the MRP. In this contribution, its application in industrial processes such as sputtering and plasma ion assisted deposition (PIAD) is presented. The probe is insensitive against dielectric coatings and can be adapted as a highly functional and fast diagnostic system for such deposition processes, where other diagnostics, e. g. Langmuir probes, fail. It can be used for real-time process monitoring and has been tested in control loops to stabilize deposition processes. Further challenges for both academia and industry are addressed such as the temperature stability. Funded by BMBF (13N13212)

Invited Talk K 7.3 Thu 11:30 MB HS

Prospects for the enhancement of PIAD processes by monitoring of optical thickness and plasma parameters — •Jens Harhausen[1], Rüdiger Foest[1], Margarita Baeva[1], Detlef Loffhagen[1], Olaf Stenzel[2], Steffen Wilbrandt[2], Christian Franke[2], Norbert Kaiser[2], and Ralf Peter Brinkmann[3] — [1]Leibniz Institute for Plasma Science and Technology, Greifswald, Germany — [2]Fraunhofer Institute of Applied Optics and Precision Engineering, Jena, Germany — [3]Ruhr University, Institute of Theoretical Electrical Engineering, Bochum, Germany

Plasma ion assisted deposition (PIAD) is a common technique employed for the production of optical interference coatings. Present control schemes concerning the plasma state focus on parameters of the supply units, such as gas fluxes, or electrical quantities. In-situ data on the growing films are obtained by quartz crystal microbalance (QCM) and optical monitoring (OM). In order to access plasma parameters during the deposition process, we employ optical emission spectroscopy (OES) and active plasma resonance spectroscopy (APRS). Data on radiance by OES and electron density from APRS are used to develop novel schemes for plasma-based control. The impact of the control procedure on the reproducibility of layer properties is discussed based on results obtained for a quarterwave stack serving as test case. In particular, it is attempted to disentangle variations in the refractive index from OM data of constant optical thickness. Results presented in this contribution are based on funding by the German Federal Ministry of Education and Research under grant 13N13213.

Invited Talk K 7.4 Thu 12:00 MB HS

Stabilisierung von Rate und Schichtdickenuniformität im IBS-Prozess über adaptiv geregelte Prozessparameter — •Florian Carstens, Henrik Ehlers und Detlev Ristau — Laser Zentrum Hannover e.V., Hannover, Deutschland

Sputter-Depositionsprozesse, insbesondere das Ionenstrahl-Zerstäuben (Ion Beam Sputtering, IBS), stellen die derzeit etablierten Verfahren dar, wenn es um die Beschichtung von optischen Komponenten zur Herstellung besonders anspruchsvoller Interferenzfilter geht. Hierbei kommt es vor allem auf eine hohe Schichtdickenpräzision und reproduzierbare Dispersionseigenschaften des Schichtmaterials an. Anders als beispielsweise beim Magnetron-Sputtern werden nach dem gegenwärtigen Stand der Technik in IBS-Prozessen materialspezifische, feste Parametersätze ohne eine In-situ-Regelung der Prozessgrößen verwendet. Eine derartige adaptive Regelung birgt jedoch ein erhebliches Potential, um eine vor allem für industrielle Anwendungen notwendige weitere Steigerung der Qualität, Reproduzierbarkeit und Ausbeute der hergestellten Beschichtungen zu realisieren. Im Rahmen des BMBF-Forschungsverbunds PluTO$^+$ wurden am Laser Zentrum Hannover verschiedene adaptive Regelungsansätze zur Stabilisierung des IBS-Beschichtungsprozesses erforscht. Mit Hilfe dieser Verfahren konnte unter anderem die Stabilität der Beschichtungsrate des Prozesses sowie die Schichtdickenuniformität auf den zu beschichtenden Optiken deutlich erhöht werden. Der Vortrag gibt einen Überblick über die verfolgten Regelungsansätze und demonstriert die jeweils erreichte Prozessstabilitätsverbesserung.

Invited Talk K 7.5 Thu 12:30 MB HS

Structural and optical properties of virtual materials — •Holger Badorreck, Marco Jupé, and Detlev Ristau — Laser Zentrum Hannover e.V., Hannover, Deutschland

Physical deposition processes for thin film optical coatings are modeled in the Virtual Coater framework. This concept combines different simulation techniques in a multi scale model, which covers the material transport in the coating plant, the atomistic growth of the thin films and electronic and optical properties of these films. The material transport is simulated by Direct Simulation Monte Carlo and the atomistic growth is performed by classical molecular dynamics. For the calculation of optical properties usually the density functional theory can be employed, but only for a limited structural size in the order of about 100 atoms. The structural properties, that cannot be described by this limited number of atoms, like voids and pores, therefore needs to be described by effective medium approximations, for example. This approach allows to describe the impact of structural inhomogeneities on the optical properties. Pores amount and orientation can be modeled to obtain direction dependent effective index ellipsoids. However, for applying the effective medium theory, the optical properties of the different dense materials need to be known, which can be obtained by the density functional theory. The possibilities and limitations of the approach are discussed.