Hard Coatings and Vapor Deposition Technologies
Room On Demand - Session B7

Plasma Surface Interactions, Diagnostics and Growth Processes

B7-1 INVITED TALK: Energy and Momentum Fluxes at Plasma Processing of Materials, ***Holger Kersten (kersten@physik.uni-kiel.de)***, *T. Trottenberg, M. Klette, L. Hansen, A. Spethmann, F. Schlichting,* IEAP, U Kiel, Germany **INVITED**

For an optimization of plasma-based processes as thin film deposition or surface modification, respectively, suitable diagnostics are required. In addition to well-established plasma diagnostic methods (e.g. optical emission spectroscopy, mass spectrometry, Langmuir probes, etc.) we perform examples of "non-conventional" low-cost diagnostics, which are applicable in technological plasma processes. Examples are the determination of energy fluxes by calorimetric probes and measurement of momentum transfer due to sputtered particles by force probes. In particular, energy and momentum transfer transport through the plasma sheath combined with the possibility to measure the effect of charge carriers as well as energetic neutrals are of interest and become possible by these diagnostics.

Total energy fluxes from plasma to substrate have been measured by special calorimetric sensors. A typical method is the passive thermal probe (PTP) based on the determination of the temporal slope of the substrate surface temperature (heating, cooling) in the course of the plasma process. By knowing the calibrated heat capacity of the sensor, the difference of the time derivatives yields the integral energy influx to the surface. Simultaneously, the electrical current to the substrate can be obtained and by variation of bias voltage the energetic contributions of charge carriers can be determined. By comparison with model assumptions on the involved plasma-surface mechanisms the different energetic contributions to the total energy influx can be separated.

Furthermore, for thin film deposition by sputtering it is essential to determine the sputtering yield as well as the angular distribution of sputtered atoms. In addition to simulations (TRIM, TRIDYN etc.) an experimental determination of the related quantities is highly demanded. For this purpose, we developed a suitable interferometric force probe. The sensitive probe bends a few µm due to momentum transfer by the bombarding and released particles, i.e. sputtered target atoms and recoiled ions. By knowing the material properties of the cantilever and by measuring its deflection, the transferred momentum, e.g. the force in µN range, can be determined experimentally. In the present study, measurements are compared with TRIM simulations for different experimental discharge conditions.

B7-3 A Force Probe as a Tool to obtain Directionally Resolved Momentum Characteristics during Sputter Processes, ***Mathis Klette (klette@physik.uni-kiel.de)***, *T. Trottenberg, M. Maas, H. Kersten,* Kiel University, Kiel, Germany

Ion beam sputter deposition is a well-established technique for producing high quality thin film coatings. The optimization of the coating process requires an understanding of the physical phenomena. Process parameters like the deposition rate can be determined by quartz crystal microbalances, while charged particles in the sputter plume can be characterized by Faraday cups or retarding field analyzers.

However, the majority of the sputter plume consists of neutral particles. Characterizing these requires much more complex diagnostics, such as optical emission, laser-induced fluorescence [1], or mass spectrometry [2].

In contrast, interferometric force probes offer a more direct measurement of all particles including neutrals by measuring the force the sputter plume exerts onto the probe surface. In previous works, these probes have been used to determine the thrust of electric space propulsion engines, forces exerted by a low-temperature plasma onto a solid boundary [3], or the recoil of reflected and sputtered particles at a sputter target [4].

In this work, a sputter plume is generated by an ion beam directed onto a rotatable copper or silver target, respectively. In order to obtain a directionally resolved momentum profile, a force probe is circling the target at a fixed distance, measuring the current and momentum transferred to the probe surface. The obtained momentum profiles are then compared with numerical simulations using SRIM [5]. Both, measurements and simulations, are carried out for different angles of incidence, ion energies, gases, target materials, and working pressures.

References

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B7-4 Erosion and Cathodic Arc Plasma of Nb–Al Cathodes: Composite vs. Intermetallic, *S. Zöhrer, M. Golizadeh,* Montanuniversität Leoben, Austria; *N. Koutná,* TU Wien, Austria; *D. Holec,* Montanuniversität Leoben, Austria; *A. Anders,* Leibniz Institute of Surface Engineering (IOM), Germany; ***Robert Franz (robert.franz@unileoben.ac.at)***, Montanuniversität Leoben, Austria

Cathodic arc deposition has been established as one of the standard techniques for the physical vapour deposition of thin films and coatings as it allows the synthesis of a wide variety of materials including metallic films, but also nitrides, carbides and oxides if a reactive background gas is used. In addition, the highly ionised plasma and the achievable high deposition rates allow a variety of control mechanisms to influence the film growth while the manufacturing costs remain rather low due to the short deposition times. With the advent of multifunctional thin films and coatings, the use of multi-element cathodes providing the non-gaseous elements during the synthesis has become an industrial standard. However, a detailed understanding of the discharge properties is vital for the further optimisation of the deposition processes to enable synthesising thin films or coatings with improved properties.

In the case of single-element cathodes, many properties of cathodic arcs show a correlation to the cohesive energy of the cathode material including the burning voltage, the erosion rate, or, to a lesser extent, plasma properties like electron temperatures or average ion energy and charge states. For multi-element cathodes, various phases with different cohesive energies can initially be present in the cathode, or form due to arc exposure, complicating the evaluation of such correlations. To test the influence of morphology and phase composition of multi-element cathodes on cathodic arc properties, we used a Nb–Al cathode model system that includes: pure Nb and Al cathodes; intermetallic Nb_3Al, Nb_2Al and $NbAl_3$ cathodes; and 3 composite Nb–Al cathodes with atomic ratios corresponding to the stoichiometric ratios of the intermetallic phases. Pulsed cathodic arc plasmas from these cathodes were examined using a mass-per-charge and energy-per-charge analyser, showing that charge-state-resolved ion energy distributions of plasmas from the intermetallic and corresponding composite cathodes are nearly identical. An examination of converted layers of eroded cathodes using x-ray diffraction and scanning electron microscopy indicates the formation of a surface layer with similar phase composition for intermetallic and their corresponding composite cathode types. The average arc voltages do not follow the trend of cohesive energies of Nb, Al and intermetallic Nb–Al phases, which have been calculated using density functional theory. Possible reasons for this effect will be discussed based on the current knowledge of multi-element arc cathodes and their arc plasma available in literature.

B7-5 Oxygen Diffusion Barrier On Interfacial Layer Formed With Remote Nh3 Plasma Treatment, ***Fu-Yang Chu (xxmoon666@gmail.com)***, *K. Chang-Liao, D. Ruan, H. Yeh, S. Yi, Y. Chien,* National Tsing Hua University, Taiwan

In this work, the effects about an additional post interfacial layer (IL) plasma treatment for germanium (Ge) n-type metal oxide semiconductor field effect transistor (nMOSFET) has been discussed in detail. It is founded that the electrical performance could be further improved by an additional plasma treatment after the traditional germanium dioxide IL formation. The Ge nMOSFET with NH3 plasma treatment exhibits higher on-off current ratio, lower subthreshold swing and higher Gm value, while the equivalent oxide thickness or gate dielectric quality might be kept.

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