PO4084

Plasma Density Monitoring of long-term PIAD Processes

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Plasma Ion Assisted Deposition (PIAD) process is mainly characterized by common e-beam evaporation in conjunction with additional ion beam bombardment targeted on the substrate surface. This bombardment increases the mobility of ad-atoms at the surface and in the bulk during the growth process of the thin film to achieve energetically advantageous positions of atoms, leading to an improved layer quality. As the properties of the ion beam can be adjusted with high accuracy, the PIAD process is quite stable, providing high precision in high-end layer systems. Nevertheless, fluctuations of plasma conditions can occur due to short-term instabilities or long-term drifts of process parameters. In case of the hot cathode dc source APS, lifetime of the electrodes is a major issue. In complex layer systems with extended deposition times of up to 18 hours, changes in lateral distribution of the coating material at the substrate level can cause deviations of layer thickness. As the layer growth is directly correlated with the plasma conditions, plasma parameters must be stabilized to reach reproducibility in coating of a batch series for long-term view. For the monitoring of plasma conditions, we installed a multipole resonance probe (MRP). This diagnostic tool is based on active plasma resonance spectroscopy, whereby a radio frequency is fed into the plasma to make use of the resonance behavior of electrons that corresponds to the plasma density in low-pressure gas discharges. Results of the MRP measurements reveal instabilities during the coating process and give insight into the dynamics of the deposition conditions over run-times of up to several hours. At LASER COMPONENTS GmbH, PIAD is employed for the manufacturing of HfO_2 and Ta_2O_5 based optical interference coatings for IR applications. Process and plasma parameters have been compared to thin-film properties and lateral distribution at the substrate level. Within the study, the MRP monitoring has proven to be a promising approach towards an implementation of a phase lock loop controlling and balancing the plasma density. This work is based on funding by BMBF under grants 13N13208, 13N13212 and 13N13213.

Keywords
APRS