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Specific plasma phenomena in magnetron sputtering systems

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The main aim of this work is to show recent developments and specific phenomena in the field of magnetron sputtering technology. In the first part we will focus on the basic principles of reactive HiPIMS method with a feedback pulsed reactive gas flow control and an optimized location of the reactive gas inlets providing the possibility to produce high-quality oxynitride films with a tunable elemental composition, structure and properties at very high deposition rates. In the second part we will focus on the dual magnetron sputtering systems which belong to advanced sputtering methods solving problems of disappearing anode and partially also arcing. Recently, a specific plasma drift has been discovered in the dual magnetron system with tilted magnetrons and we will discuss specifics, properties and consequences of this phenomenon for thin-films deposition.

High-power impulse magnetron sputtering (HiPIMS) methods currently constitute an intensively developing area of magnetron sputtering technologies. However, deposition of dielectric oxide coatings using HiPIMS at high-powers (a peak value of the target power density of up to several $kWcm^{-2}$ in a pulse) is challenging due to significant arcing on the target surface. To avoid this problem and to achieve high deposition rate of the films, our group has proposed a solution based on the reactive HiPIMS with a feedback pulsed reactive gas (oxygen and/or nitrogen) flow control and an optimized location (high-density plasma zone) of the reactive gas inlets in front of the target. It will be shown that this way it was possible to produce high quality Hf-O-N films with a tunable elemental composition, structure and properties at very high deposition rates ranging from 175 nm/min for HfN films to 230 nm/min for HfO_2 films [1]. The method is based on the following principles: i) intense sputtering of atoms from the target resulting in a substantially increased deposition rate, ii) very high degree of dissociation of both O_2 and N_2 molecules in a discharge plasma, resulting in a replacement of O_2 and N_2 molecules, which have very different reactivity with metal atoms on the surface of the growing films, by atomic O and N, which have similar reactivity, and iii) strong “sputtering wind” of the sputtered atoms resulting in a reduced flux of the reactive gas particles onto the target substrate.

In the second part we will focus on the phenomena occurring in the dual magnetron (DM). The DM is an advanced sputtering system which is effectively used for the deposition of thin films, particularly oxides and multiphase coatings [2]. Main advantages of this sputtering source lie in the suppression of arcing on the surface of the magnetron target and in the elimination of the disappearing anode effect, which is an issue in the reactive sputtering of electrically insulating oxides using a single magnetron. In this study we focus on the effect of the polarity of magnets on the performance of the DM, especially on the current-voltage characteristics and the deposition rates. A special attention will be devoted to the effect of the plasma drift [3] on the deposition process. This phenomenon occurs in the DM when the magnetrons are tilted as displayed in the Fig.1.

Fig.1. Side view photograph of the dual magnetron with closed magnetic field and tilted magnetrons.

References

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