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The Influence of the Target Age on Laterally Resolved Ion Distributions in Reactive Planar Magnetron Sputtering

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Magnetron sputtering is one of the most widely used technologies to deposit high-quality films on large areas and with high rates. This method often benefits from the direct contact between the sputtering discharge and the surface of the growing films because those are subject to the impingement of energetic particles from the plasma. In many cases, the film properties can be tailored by the application of a substrate bias voltage which is used to control the energy of the positive ions originating from the plasma bulk of the sputtering discharge and accelerated to energies between 10 and some 100 eV. However, neutrals, positive ions and especially negative ions formed near to or at the target surface may exhibit energies much higher than 100 eV. Such particle energies severely impair the film quality particularly in electronically active thin films such as used in photovoltaics or microelectronics through the creation of defects by radiation damage. To precisely control the film properties the formation mechanisms of these high-energetic species have to be known. However, a general picture is difficult to obtain because the erosion state of the target may differ for different investigations making the results difficult to compare.
In this paper, ion distributions at the substrate for a planar magnetron are presented. Ion distributions for negative as well as positive ions were measured with an energy-dispersive mass spectrometer (plasma monitor) facing the target surface. The magnetron was moved perpendicular to the axis of the plasma monitor to obtain ion distributions for different positions relative to the race track of the target. The targets used were either new ones with a plane surface or sputtered for a long time with a developed erosion groove along the race track. Generally, the distributions of positive ions are dominated by low energies with occasional high energy contributions up to about 100 eV. Negative ions typically exhibit three distinct contributions with high, medium and low energy. These are shown to be strongly dependent on the position at the substrate and significantly change their intensity with the erosion state of the target. Hence, the energy deposition pattern on growing films will be altered significantly during the lifetime of a target. Formation mechanisms of the different ion ensembles are discussed.

Keywords
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negative ions

ion distribution