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Physics of High Power Impulse Magnetron Sputtering

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Over the last decade, high power impulse magnetron sputtering (HIPIMS) has emerged as an exciting new coating technology that combines traditional magnetron sputtering with pulsed power technology. As a result, the flux of sputtered atoms is at least partially ionized thereby providing an elegant means for self-ion-assisted deposition. The underlying physics of the magnetron discharge under high pulse power conditions is generally understood although it turns out to be quite complicated and greatly depending on the target material properties as well as on the characteristics of the discharge power supply.

In this overview presentation, we start from conventional magnetron operation, with particular emphasis on sputter yields, secondary electron emission, electron magnetization, ionization of background gas, and gas rarefaction. All of those conditions are greatly affected when going to a high power impulse regime. The word “impulse” refers here to a pulse operation of low duty cycle and very high peak power. The most important effect we seek is the ionization of the sputtered atoms. Other, new effects appear too, such as transient gas compression and rarefaction, self-sputtering, self-sputtering runaway for high-yield targets, enhancement of gas activation (excitation and ionization), multiple ionization for low-yield materials, and plasma instabilities at high power levels. The richness of the effects will be illustrated by numerous examples, and some comparison is made to other condensing plasmas such as (filtered) cathodic arc plasmas. The overview is concluded with a consideration of deposition rates impacting the economics and market penetration of this technology.

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