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For film synthesis by energetic condensation, it is necessary to produce plasmas with a high degree of ionization. Of particular interest is the ionization of the condensing species, such as metal ions, because this allows us to control the particle energy distribution with electrical fields (bias), and the particle spatial distribution with magnetic fields. This has great consequences for film density, stress, texture, interface engineering, as well as film uniformity.

The most straightforward approach towards a high degree of ionization is to increase the power density by orders of magnitude beyond "typical" discharge power, thereby shifting the electron distribution function and enhancing the probability of ionizing collisions. This is well established in pulsed power physics, and has been studied for decades in z-pinches, wire-explosions, laser ablation plasmas, pseudo-sparks, cathodic arcs, etc. About a decade ago, the concept has been transferred to magnetron sputtering, leading to high power impulse sputtering (HIPIMS). Following the path of a sputtered atom, we recognize that the mean free path between inelastic collisions must be short compared to the characteristic length of the magnetic field structure that keeps the electrons in a closed drift region. This criterion implies a high density of to-be-ionized atoms as well as a significant population of energetic electrons. The realization of both is accomplished by dissipating power in a small volume: the rate of sputtering increases, enabling self-sputtering and enhancing the density of to-be-ionized metal atoms, and the energy of electrons is enhanced, too. Due to the high power load on the metal target, the very high power density can only be sustained in a transient manner, leading to the pulsed nature of this technology.

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