High Power Impulse Magnetron Sputtering - the Age of Adolescence

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High power impulse magnetron sputtering (HIPIMS) is one of the youngest sputtering technologies for thin film deposition. It provides a new deposition parameter space which is unattainable by conventional technologies and results in unique material properties.

Magnetron sputtering devices confine plasmas in an **E**×**B** field where the cathode is planar and the magnetic field is arranged in a closed loop tunnel along the solid surface. The plasma sputter-erodes the cathode to produce a deposition vapour.

HIPIMS is operated in a magnetron sputtering configuration but utilises a short (impulse) quasi-stationary gas discharge with duration of ~100 μs and duty cycles of <1% reaching high peak power densities of 3000 Wcm^{-2} at the cathode at voltages of several hundred volts. Within each HIPIMS pulse the discharge is ignited through an electron ionisation wave and then develops into a cold metal plasma. The properties of the target material such as sputter yield, atomic mass and ionisation potential determine film growth conditions at the substrate.

The timescales are sufficient to produce dense metal plasma of 10^{13} cm^{-3} whilst avoiding excessive heat buildup and glow-to-arc transitions on the cathode. The plasma pressure may exceed the confinement fields causing localised rupture and intense particle emission. The emission points organise themselves on the crests of a wave propagating in the **E**×**B** direction whose velocity is related to the ionisation degree.

HIPIMS plasmas can induce a metal implantation zone of a few nanometres to promote adhesion of the coating to the substrate by producing a crystalline interface and a chemical environment for better wetting during film nucleation which result in local epitaxial growth.

At highly ionised conditions Nb films have better crystallinity and superconducting properties. Better coverage of meshes and high aspect ratio vias is achieved.

In reactive conditions, deposition flux contains highly dissociated nitrogen which promotes a 200 crystallographic texture and fully dense column boundaries in TiN monolithic films.

Nanolayered CrN/NbN and CrAlN/CrN developed with low roughness and enhanced density making them suitable for biological and high-temperature oxidation environments.

Industrial uptake is rife in the fields of hard coatings and microelectronics with a number of vendors providing turn-key solutions and products made with HIPIMS technology.