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Process optimization of Ti-based compound films in HiPIMS

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Titanium-based compound materials, such as TiN, TiO_2, TiO_xN_y, show excellent mechanical, tribological, optical and photocatalytic properties, making them very useful as thin films in a wide range of applications. These films are usually prepared by plasma-based methods including reactive High Power Impulse Magnetron Sputtering (HiPIMS). HiPIMS plasmas exhibit a high ionization fraction of the sputtered material as well as high kinetic ion energies. In the case of Ti, the ionization fraction typically exceeds 60% but has been shown to reach above 90%. The high degree of ionization in HiPIMS allows for control of the energy and direction of the film-forming species, which results in higher film density, higher hardness, lower electrical resistivity, lower surface roughness, etc. Reactive HiPIMS has also other advantages over conventional techniques, such as eliminated/reduced hysteresis and stable high-rate deposition in the transition mode, which are key ingredients for increased productivity. However, the energetic ions are also responsible of promoting high-energy phase selective growth, e.g., rutile instead of anatase in TiO_2, and considerable intrinsic compressive stress, leading to film delamination, e.g., in TiN coated tools. Moreover, the deposition rate for Ti-based compounds are often lower in HiPIMS compared to competing techniques. In this contribution, we address these issues by identifying suitable operating conditions (pulse parameters, substrate biasing, and working pressure) to minimize, or eliminate, the undesirable effects. This includes new routes to depositing phase pure anatase TiO_2 films with improved crystal quality at high deposition rates using ion bombardment of weak to moderate intensity. In addition, new results on intrinsic stress tailoring will be presented when using advanced HiPIMS substrate biasing techniques during growth of TiN.

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