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Deposition of hard and dense nanocomposite Ti-Si-N films by DOMS without the need of energetic bombardment

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Nanocomposite Ti-Si-N thin films have been extensively studied for more than two decades mainly aiming at the production of super hard materials for applications such as cutting tools. In a previous work about the deposition of Ti-Si-N films by DOMS (Deep Oscillation Magnetron Sputtering), the authors have shown that, at low peak power, an optimal compromise of ionization fraction and the energy of the sputtered species can be achieved at low peak power. Recently, the authors have also shown that the use of low peak powers in DOMS of Cr coatings allows for control of the shadowing effect and to deposit dense films without the need of an energetic bombardment. The main objective of the present work is to further investigate the low peak power regime in the deposition of Ti-Si-N films by DOMS and to evaluate the role of the atomic shadowing effect in this regime.
All the Ti-Si-N deposited in this work have a fine compact columnar morphology with V-shaped columns, as shown by both SEM and Bright-field TEM. The Ti-Si-N films deposited in the low peak power regime have much sharper and thinner column boundaries (1 nm wide). EELS analysis shows that Si is preferentially segregated to the column boundaries, constituting a SiNx tissue phase, while the columns have a heterogeneous Ti/Si elemental ratio. The films have a high quality mosaic structure, consisting of grains only slightly misoriented with respect to each other, as confirm by TEM and XRD. The bi-axial compressive stresses increase strongly at low peak power, while only moderate increases of the lattice parameter and the hardness are registered. The results show that, in the low peak power deposition regime, the atomic shadowing effect is prevented rather than counteracted by an energetic bombardment. Thus, the low energy of the bombarding species is sufficient to promote the mobility of the film forming species without inducing subplantation.

Keywords
Ti-Si-N
HiPIMS
DOMS