Spectral selectivity of unbalanced magnetron sputtered TiN, TiAlN and TiAlSiN coatings: XRD, SEM and optical analyses

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Abstract: The photothermal industries require high quality and highly efficient solar selective coatings for the surface of solar energy converters. An efficient selective surface has high absorptance in the visible range and low emittance in the infrared~far-infrared range of the solar spectrum. The low emittance (or high reflectance) of such coatings would significantly reduce energy loss through infrared radiation.

In this paper, we highlight the recent development of utilizing transition metal nitride based coatings as solar selective surface, summarize their selective performances, address the challenges and issues relevant to such coatings and potential identification of the technical features to overcome these limitations for selective surface applications. TiN, TiAlN (Al concentrations vary from low to high atomic %) and TiAlSiN coatings synthesized on AISI M2 steel substrate via unbalanced magnetron sputtered technology were investigated for selective solar surface applications. X-ray diffraction, scanning electron microscopy, UV-Vis spectroscopy, FTIR spectroscopy were carried out to explore the crystalline structure, surface morphology, and optical selectivity of the coatings.

Optical studies showed that the optical absorptance, in the visible range, of the TiN coatings improved significantly from 25% to 74% with increasing Al-doping. However, an increase of optical absorptance of up to 50% resulted from coatings dopped simultaneously with Al and Si. With the high Al-content, the optical emittance, in the infrared range, of TiN coatings decreased from 4.5% to 3.4% whereas simultaneous addition of Al and Si to the TiN coatings resulted in a reduction of the emittance down to 4%. The highest optical selectivity of 21.76 was achieved with Al doping and 12.50 with simultaneous Al and Si doping to the TiN matrix.

Keywords: magnetron sputtering, thin film coatings, optical properties, solar absorptance, solar emittance, optical selectivity, selective solar surface, scanning electron microscopy, UV-Vis spectroscopy, FTIR spectroscopy.