Phase formations in tungsten carbide films deposited by reactive magnetron sputtering

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The tungsten carbide films were deposited by reactive magnetron sputtering in an industrial-scale coating chamber at different bias voltages and gas (argon/acetylene) flows. As substrate materials, silicon wafers and 100Cr6 steel sheets were used. The films were characterized using electron probe microanalysis with wavelength-dispersive X-ray spectroscopy (EPMA/WDX) and *in situ* high-temperature X-ray diffraction (HTXRD). EPMA revealed the chemical composition of the films; HTXRD gave overview over the thermally activated phase transformations and stabilization of metastable phase through the microstructure defects. The as-deposited films contain metastable phases WC_{1-x} and W_2C with distorted crystal structures. With increasing temperature and/or longer annealing time, the crystal structure of the high-temperature W_2C phase recovered, although the annealing temperature was below the temperature, which is required to make W_2C thermodynamically stable. The density of the microstructure defects in W_2C was reduced, but some defects persisted. The structure relationships between individual phases will be discussed. Further heat treatment resulted in a decomposition of W_2C, which was accompanied by the formation of metallic tungsten. The EPMA results confirmed that this decomposition is accelerated by the reaction of carbon with oxygen impurities in the annealing atmosphere. When the 100Cr6 steel is used as substrate material, W_3Fe_3C forms at the interface between the substrate and the coating. The presence of this carbide influences the decomposition of W_2C.

Keywords: tungsten carbide; thin film; sputtering; phase transformations; x-ray diffraction