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**TRIBOLOGICAL PROPERTIES OF TUNGSTEN NITRIDE FILMS AT TEMPERATURES UP TO 500°C**

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The paper reports on friction coefficient  $\mu$  and wear rate  $k$  of  $WN_x$  films with a stoichiometry  $x=N/W$  varying from 0 to 1.5 and measured at temperatures ranging from RT up to 500°C. The  $WN_x$  films were reactively sputter deposited in an Ar + N<sub>2</sub> gas mixture onto Si(100) substrates using an unbalanced magnetron equipped with a W target ( $\varnothing$  100 mm) and powered by the AC pulsed power supply operated in an unipolar mode at frequency 125 kHz with repetition frequency of pulses  $f_r = 1$  kHz. The properties of  $WN_x$  films were characterized by (i) X-ray diffraction (XRD), (ii) Scanning Electron Microscopy (SEM) and (iii) pin-on-disk tribometry. It was found that (1)  $WN_x$  films are polycrystalline nanocomposites composed of a mixture of (i) low-T  $\alpha$ -W and high-T  $\beta$ -W<sub>2</sub>N phases at  $x \leq 0.5$  and (ii) high-T  $\beta$ -W<sub>2</sub>N and low-T  $\delta$ -WN phases at  $0.5 < x \leq 1.5$ , (2) the friction coefficient  $\mu$  of  $WN_x$  films increases with increasing  $x$  from 0.26÷0.42 at RT to 0.75÷1.23 at 150°C and decreases to about 0.50 with temperature increasing above 150°C up to 400°C due to the growth of a WO<sub>y</sub> scale on the film surface, (3) the wear rate  $k$  of  $WN_x$  films increases from about 10<sup>-7</sup> mm<sup>3</sup>/Nm at 150°C up to about 2.5×10<sup>-6</sup> mm<sup>3</sup>/Nm at 400°C, (4) the wear rate  $k$  of the  $WN_x$  film at given temperature is the lower, the lower is its stoichiometry  $x$ , (5) the wear rate  $k$  of the  $WN_x$  films with  $x \leq 0.27$  at T≤75°C is 10 up to 100 times higher than  $k$  of  $WN_x$  films with  $x \geq 0.64$ , and (6) the  $WN_x$  films with  $0.2 < x \leq 1.5$  are completely removed from the substrate at T=450°C due to the formation of the WO<sub>y</sub> scale on the film surface already at sliding distances of 350 to 600m.

**Keywords**

Tungsten nitride

Tribological

High temperature

Pulsed magnetron sputtering

Thin films