Improved Hardness and Tribological Properties and Detailed Surface Analyses of Niobium Treated by High Temperature Plasma Based Ion Implantation

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Abstract

Niobium, a refractory metal, presents a series of outstanding properties: high melting point, high electrical conductivity, good corrosion resistance, malleability and high hardness. As an alloying element it is used in several modern technologies, like in aviation manufacture, space-system engineering,construction of pipelines and as structural components in modern automobiles. Nevertheless, niobium is oxidized at 400 C, and usually a protective coating is demanded for applications in high temperature to prevent the material to become brittle. Transition metal nitrides, as is the case of NbN, exhibit an attractive mixture of physical, chemical and mechanical properties and can be used to overcome such constraint. Several methods such as reactive magnetron sputtering technique, pulsed laser deposition and vacuum arc deposition are used for producing NbN thin films. Plasma based ion implantation (PBII) is a very convenient and efficient method for surface modification of materials. In this method work-pieces with complex surface contours can be homogeneously treated without dimensional variation and avoiding adhesion problems, since there is no film growth. In this work high temperature nitrogen implantation into niobium was performed in a PBII system at the temperatures of 1000 and 1250 C, respectively. In the process, negative pulses of 10kV/20μs/500Hz were applied to Nb samples for 1 hour. The heating was accomplished by electron bombardment during pulse off time. X-ray diffraction spectra revealed the presence of ϵ-NbN, β-Nb2N and γ-Nb4N3 phases. Wear rate was reduced from 2.44 mm3/N.m up to 0.25 mm3/N.m for treated samples in comparison with pristine samples, while friction coefficient (μ) was reduced from $\mu = 0.8$ to $\mu = 0.25$. Hardness was significantly increased. A threefold increase of the surface roughness was measured by optical profilometry for samples treated at 1250 C in comparison with untreated samples and the ones treated at 1000 C.

Keywords: niobium nitride, tribological properties

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