OPTICALLY TRANSPARENT Zr(Si)BN HARD FILMS FOR PROTECTION OF SOLAR CELLS*

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Research and development of new protective materials is being conducted in a new direction related to solving the global problem of the impact of space debris particles and micrometeoroids on spacecraft. The use of special maneuvering in orbit, as well as protective systems (Whipple shielding) does not completely avoid the damaging effects of small abrasive particles. The optical devices of spacecraft are particularly vulnerable. Thus, there is an urgent need to find new ways and materials to protect the solar cells. Protection of optical devices (portholes and solar cells of spacecraft, as well as solar power stations, solar collectors, etc.) from abrasive effects can be provided by the use of wear - and erosion-resistant ion-plasma coatings, including those based on oxygen-free ceramics. The use of hard and optically transparent ZrB(Si)N films is promising.

Films were deposited by DC and pulsed DC magnetron sputtering of ZrB_2, ZrB_2+20%Si, and ZrB_2+50%$ZrSi_2$ targets in Ar+N_2 gas mixtures [1-4]. The targets were manufactured by means of self-propagating high-temperature synthesis. The structure, chemical and phase composition of films were studied by HR TEM, XRD, SEM, EDS, XPS, Raman and FTIR spectroscopy, and GDOES. The films were characterized using nanoindentation, sliding pin-on-disk, impact ball-on-plate, abrasive calowear, and scratch tests. The refraction index, coefficients of transmittance (Tr) and reflectance were measured by KFK-3 and Cary 5000 Agilent + UMA attachment for wavelength range from 200 to 2500 nm.

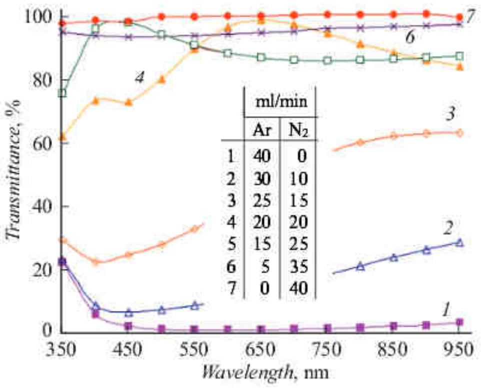

Fig.1. Transmittance vs. wavelength dependence for films deposited at different nitrogen flow rates [1].

Results obtained show that films deposited at low nitrogen partial pressure predominantly consist of nanocrystallites of hexagonal ZrB_2-phase, 1-20 nm in size and amorphous regions. N-rich films exhibit fully amorphous structure. Specific optical properties were observed for these ZrBN and ZrBSiN coatings including Tr=70-100% (Fig.1). The hardness of 15-37 GPa and Young's modulus of 150-470 GPa were determined for films deposited onto alumina substrates. Coatings demonstrated friction coefficient 0.2-0.4. The addition of nitrogen significantly increased wear resistance in sliding and impact conditions.

REFERENCES

[1] Ф.В. Кирюханцев-Корнеев и др. ПЖТФ, 2020, том 46, вып. 4 с. 30-32

[2] F. V. Kiryukhantsev-Korneev et al. Physics of Atomic Nuclei, 2019, V 82, No. 11, pp. 1437–1440

[3] I.V. Iatsyuk et al. IOP Conference Series: Materials Science and Engineering 347 (2018) 012028

[4] F. V. Kiryukhantsev–Korneev et al. Protection of Metals and Physical Chemistry of Surfaces, 2018, Vol. 54, No. 6, pp. 1147–1156

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