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Hard nanocrystalline Zr-B-C-(N) films with high electrical conductivity prepared by pulsed magnetron sputtering

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Hard Zr-B-C-(N) films were deposited on Si(100) substrates by pulsed magnetron co-sputtering of a single B_4C-Zr target (127 x 254 mm^2) in various nitrogen-argon gas mixtures. The target was formed by a B_4C plate overlapped by Zr stripes which covered 15 or 45 % of the target erosion area. The N_2 fractions in the gas mixture were in the range from 0 to 50 % at the total pressure of the gas mixture of 0.5 Pa. The planar rectangular unbalanced magnetron was driven by a pulsed DC power supply (Rübig 120 MP) operating at the repetition frequency of 10 kHz and the average target power of 500 W in a period with a fixed 85% duty cycle. The substrates were at a floating potential and were heated to 450˚C. The target-to-substrate distance was 100 mm. The elemental composition of the films was determined by Rutherford backscattering spectrometry. X-ray diffraction measurements of as-deposited samples were carried out using a PANalytical X'Pert PRO diffractometer. Hardness, reduced Young's modulus and elastic recovery were determined by a Fischerscope H-100B ultramicroindenter. Electrical resistivity was measured by four-point method. Hard (37 GPa) nanocrystalline Zr-B-C films with very low compressive stress (0.4 GPa) and high electrical conductivity (resistivity of 2.3×10^{-6} Ωm) were deposited in argon discharge at the 15 % Zr fraction in the target erosion area. Hard (37 GPa) nanocomposite Zr-B-C-N films with low compressive stress (0.6 GPa) and even higher electrical conductivity (resistivity of 1.7×10^{-6} Ωm) were deposited at the 45 % Zr fraction in the target erosion area and 5 % N_2 fraction in the gas mixture. The former films exhibited very high oxidation resistance in air up to 650˚C, while the latter to 550˚C.

Keywords
Nanocrystalline Zr-B-C-(N) films
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