C4-O-037801

TAILORING OF OPTICAL, MECHANICAL AND SURFACE PROPERTIES OF HIGH-ENTROPY CERAMIC THIN FILMS*

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Materials with a combination of high hydrophobicity, enhanced mechanical properties (hardness, toughness) and thermal stability find a various application in industry.

The group of the low-electronegativity metals oxides exhibit the hydrophobic effect. It is possible to enhance the mechanical properties of this group of ceramics without a weakening of the hydrophobic effect [1]. Several methods of the mechanical properties enhancement can be used for non-polymer thin films. One of the most promising is the entropy stabilization. High entropy alloys are surpassing traditional alloys and compounds in thermal stability and mechanical properties, making them potential high performance constructive and functional materials.

In order to create a robust transparent hydrophobic ceramic for the selection of the high entropy oxide (HEO) composition we used the combination of three material properties: a high melting temperature of the oxide, the lowest enthalpy of formation (or minimum Gibbs free energy per mole O_2) and low electronegativity of the base element. Resulted group of the selected oxides was taken as HfO_2, ZrO_2, Y_2O_3 and CeO_2, excluding radioactive ThO_2 and PuO_2 and toxic BeO.

In this work we performed a series of experiments devoted to change in optical, mechanical and surface properties depending on the Hf-Zr-Ce-Y-O thin film composition. The magnetrons were powered by high power impulse magnetron sputtering (HiPIMS) power supply.

$Hf_4Zr_4CeY_2O_{21}$ shows up to three times higher hardness compared to binary $HfZrO_4$ oxide and up to 50% higher hardness compared to cubic ZrO_2 and HfO_2 due to the solid solution hardening effect. Equimolar film exhibit a high transmittance >85% and high hydrophobicity with the water contact angle ≈ 106°. Variation of the elemental composition in Hf-Zr-Ce-Y-O is allows to simultaneously tune mechanical and wetting properties for the optimum configuration depending on the application.

REFERENCES

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* The work was supported by RFBR, project number 19-29-13034. The thin films growth equipment was created with the support by Tomsk Polytechnic University development programs.