Mechanical properties and thermal stability of ZrBSiTaN films

Kuo-Hong Yeh[1], Li-Chun Chang[2,3], and Yung-I Chen[1,4,*]

[1]Department of Optoelectronics and Materials Technology, National Taiwan Ocean University, Keelung 202301, Taiwan.

[2]Department of Materials Engineering, Ming Chi University of Technology, New Taipei 243303, Taiwan.

[3]Center for Plasma and Thin Film Technologies, Ming Chi University of Technology, New Taipei 243303, Taiwan.

[4]Center of Excellence for Ocean Engineering, National Taiwan Ocean University, Keelung 202301, Taiwan.

ZrBSiTaN films were fabricated on silicon and AISI 420 stainless steel substrates through direct current magnetron co-sputtering. ZrB_2, Ta, and Si targets were used. The power applied on the Si target and the nitrogen flow ratio of the reactive gas were the variables in the sputtering processes. The effects of Si and N contents on the mechanical properties and thermal stability of ZrBSiTaN films were investigated. The results indicated that all the as-deposited ZrBSiTaN films formed amorphous structures. The supplement of reactive gas with a nitrogen flow ratio of 0.4 resulted in that the ZrBSiTaN films exhibited a high N content of 60 at.%. The increase of Si content from 0 to 42 at.% in ZrBSiTa films decreased the hardness and Young's modulus values from 19.1 to 14.3 GPa and 264 to 242 GPa, respectively, whereas the increase of Si content from 0 to 21 at.% in ZrBSiTaN films increased the hardness and Young's modulus values from 11.5 to 14.0 GPa and 207 to 218 GPa, respectively. The amorphous BN and SiN_x phases played the vital role in the variations of structural and mechanical properties of ZrBSiTaN films. The thermal stability test was conducted at 800 °C for 10 min within purged Ar gas in a rapid thermal annealing furnace. The ZrBSiTa films oxidized with the residual oxygen in the vacuumed furnace, which was accompanied with the formation of ZrO_2, Ta_2O_5, and $TaSi_2$ phases, whereas the ZrBSiTaN films maintained amorphous structures. Further exploration on the oxidation behavior of ZrBSiTaN films will be studied.