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Structure and properties of ion-assisted and co-sputtered Ti-Zr-B hard and superhard coatings

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Ti-Zr-B films including TiB2-Zr composite, TiZrB2 solid solution, and TiB2/ZrB2 multilayer films were deposited by co-sputtering targets of TiB2 and Zr as well as TiB2 and ZrB2 under various substrate bias voltages. Zr and Ti are in the same group in the periodic table. Zr/Ti atoms may occupy either substitutional or interstitial positions in the lattice forming (TixZr1-x)B2 solid solution. The range of substrate voltage explored is from 0 to -200 V. The bias voltage between -90 and -120 V is appropriate for optimal film mechanical properties. For example, under a substrate bias of -95 V, the films of ˜3 at% of Zr in TiB2 exhibit (TixZr1-x)B2 solid solution phase with strong (0001) preferred orientation and achieved the highest hardness of 52 GPa with ˜ 2 GPa of compressive stress and a surface roughness of 0.3 nm. In contrast, the film prepared without substrate bias is randomly oriented and not a solid solution and possesses only 19 GPa in hardness, 0.25 GPa of tensile stress and a surface roughness of 3.0 nm. The results show that the crystal preferred orientation, crystallinity, composition, grain size, surface roughness, stress, toughness, and hardness of the Ti-Zr-B films are greatly affected by the ion bombardment on the growing film.

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