MICROSTRUCTURE AND MECHANICAL PROPERTIES OF ATOMIC LAYER DEPOSITED ALUMINA DOPED ZIRCONIA

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Tetragonal and cubic ZrO_2 polymorphs, attainable by doping with Al_2O_3, exhibit higher stiffness and hardness than the otherwise stable monoclinic phase [1]. In this study, ZrO_2 films atomic layer deposited to the thickness of 100 nm were doped by various contents of Al_2O_3 between layers of ZrO_2. The content of Al_2O_3 was between 4.6 and 24.8 mol.% in the films. Undoped ZrO_2 film consisted of a mixture of monoclinic and tetragonal phases, whereas doping with 4.6 mol.% of Al_2O_3 resulted in the stabilization of tetragonal and possibly cubic phases of ZrO_2. Further increase in the content of Al_2O_3 resulted in cubic phase and the appearance of amorphous ZrO_2. Mixing ZrO_2 with 12.8 and higher mol.% of Al_2O_3 showed only X-ray amorphous films. All the crystalline films exhibited preferred crystal orientations with extents differing near the substrates and the surface of the films.

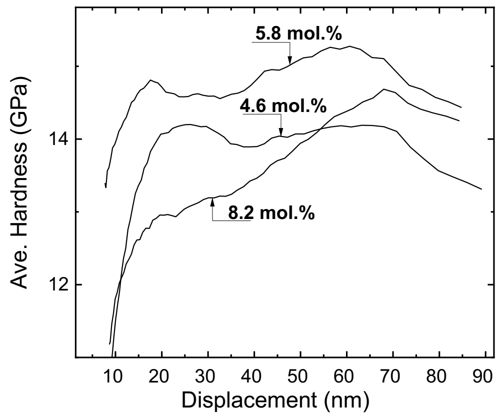

Fig.1 Averaged hardness of 30 indents on the doped crystalline zirconia films with varying amounts of alumina.

The crystalline doped films possessed higher hardness (14 – 15 GPa) compared to the amorphous ones (11 – 12 GPa), while the Young's modulus (165 ± 10 GPa) of the doped films seemed unaffected by the Al_2O_3 content or phase composition. Undoped ZrO_2 film exhibited lower hardness and stiffness than the doped films. The hardness of doped crystalline films increased in the vicinity of the substrate (Fig. 1) even though the hardness of the substrates (12.6 GPa) was lower compared to that of the films. This was explained by the change of preferential crystal orientation near the substrate.

References

1. G. Cousland, X. Cui, A. Smith, A. Stampfl, C. Stampf, 2018, *J. Phys. Chem. Solids,* 122, 52

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