Synthesis, microstructure and properties of Cr-based mixed oxide thin films using reactive r.f. magnetron sputtering

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New oxide-based thin films with tailored microstructure and properties achieved by systematic control of cation or anion substitution are currently gaining significant interests. Such materials have in principle been demonstrated for example in the Al-Cr-O and Al-Cr-O-N systems, especially for thin films with single-phase corundum structure.

In this presentation, we will show detailed results of the synthesis and analysis of Cr-Me-O (Me = Zr, V) thin films. In order to cover a wide range of film compositions, a combinatorial approach was applied. To realise this, a segmented target consisting of a half plate Cr and a half plate Zr, or V, was used. An r.f. target power of 500 W was applied and the gas pressure kept constant at 0.4 Pa (using an Ar/O_2 mixture). The substrate temperature was set at 500 °C for Cr-Zr-O and at 350 °C for Cr-V-O films. The bias voltage was set at 0 V and -50 V.

In case of Cr-Zr-O films deposited at 0 V substrate bias, electron probe microanalysis showed a clear shift of the metal/non-metal concentration ratio from 2/3 (for Cr-rich films) to 1/2 (for Zr-rich films). XRD and TEM showed that Cr-rich films were grown in a single-phase $(Cr,Zr)_2O_3$ corundum structure with a maximum Zr incorporation of about 12 at.%. Zr-rich films formed a $(Zr,Cr)O_2$ structure with a maximum Cr incorporation of about 7 at.%. In Cr-V-O films, the metal/non-metal concentration ratio shifts from 2/3 (Cr-rich) to about 2/5 (V-rich). The Cr-rich film showed a single-phase corundum structure with a maximum V incorporation of about 4 at.%. With increasing V content the films became X-Ray amorphous. At a moderate bias voltage of -50 V both the Cr-Zr-O and Cr-V-O films with a single-phase corundum structure showed hardness values above 20 GPa indicating a potential for applications as hard protective coatings.