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Thermal conductivity of nitride based thin films

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The rapidly growing development on nitride based thin films has led to a great variety of applications, where either high or rather low thermal conductivity is required. On one side of the scale are wurtzite AlN thin films, which have drawn great attention over the last decades due to its extremely high thermal and rather low electrical conductivity.On the other side of the scale are cubic Ti- and Cr-nitride-based thin films (~4W/mK), which are well-established in milling applications due to their outstanding thermo-mechanical properties.Within this study, we investigated the influence of the alloying content on the temperature dependent thermal conductivity in Ti-, Al-, and CrN based coatings. Therefore, a PVD reactive magnetron sputtering system was applied to deposit c-TiN, c-Ti0.40Al0.60N, w-AlN, w-Al0.95Cr0.05N, and c-CrN thin films. For determination of the thermal conductivity, the 3-omega method was applied. Calculations on the thermal conductivity measurements of AlN thin films predict that the used setup is limited to a measureable thermal conductivity of ~50W/mK, which is clearly exceeded by our AlN thin films. These results were correlated with the structural and mechanical properties of the coatings obtained by XRD, SEM, TEM, and nanoindentation analysis. Doping small amounts of 5at.% Cr into AlN thin films has no effect on the single phased wurtzite structure, which is also obtained for pure AlN. But regardless of the similar crystal structure and morphology, the 3-omega measurement reveals a significant drop in the thermal conductivity compared to AlN. The impurities and/or point defects have a pronounced impact on the mobility of phonons, being the major carrier for thermal conductivity in electrically insulating materials. By using the 3-omega method it is possible to accurately measure the thermal conductivity of nitride based thin films in a wide temperature range.

Keywords
thermal conductivity, 3-omega method, mechanical properties