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Fabrication of Aluminum Nitride Thick Layers by Modified Reactive Plasma Spraying

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Abstract : Hexagonal aluminum nitride (AlN) is a promising candidate for several wide band gap semiconductor compound applications such as deep UV light emitting diodes (UVC LED) and fast power transistors (HEMTs). To date, bulk AlN single crystals are still commonly grown from the physical vapor transport (PVT). Single crystalline AlN wafers obtained from this process could offer suitable substrates for a defect-free growth of ultimately active AlGaN layers, however, these wafers still lack from small sizes, limited delivery quantities and high prices so far.Although there is already an increasing interest in the commercial availability of AlN wafers, comparatively cheap Si, SiC or sapphire are still predominantly used as substrate material for the deposition of active AlGaN layers. Nevertheless, due to a lattice mismatch up to 20%, the obtained material shows high defect densities and is, therefore, less suitable for high power devices as described above. Therefore, the use of AlN with specially adapted properties for optical and sensor applications could be promising for mass market products which seem to fulfill fewer requirements. To respond to the demand of suitable AlN target material for the growth of AlGaN layers, we have designed an innovative technology based on reactive plasma spraying. The goal is to produce coarse grained AlN boules with N-terminated columnar structure and high purity. In this process, aluminum is injected into a microwave stimulated nitrogen plasma. AlN, as the product of the reaction between aluminum powder and the plasma activated N2, is deposited onto the target. We used an aluminum filament as the initial material to minimize oxygen contamination during the process. The material was guided through the nitrogen plasma so that the mass turnover was 10g/h. To avoid any impurity contamination by an erosion of the electrodes, an electrode-less discharge was used for the plasma ignition. The pressure was maintained at 600-700 mbar, so the plasma reached a temperature high enough to vaporize the aluminum which subsequently was reacting with the surrounding plasma. The obtained products consist of thick polycrystalline AlN layers with a diameter of 2-3 cm. The crystallinity was determined by X-ray crystallography. The grain structure was systematically investigated by optical and scanning electron microscopy. Furthermore, we performed a Raman spectroscopy to provide evidence of stress in the layers. This paper will discuss the effects of process parameters such as microwave power and deposition geometry (specimen holder, radiation shields, ...) on the topography, crystallinity, and stress distribution of AlN.

Keywords : aluminum nitride, polycrystal, reactive plasma spraying, semiconductor

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