A model of morphology evolution in the growth of polycrystalline β-SiC films

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Abstract

The growth of β-SiC films via chemical vapor deposition (CVD) has been under intensive investigation because this is viewed to be an enabling material for a variety of new semiconductor devices in areas where silicon cannot effectively compete. However, the difficulty in achieving single-crystal or highly textured surface morphology in films with low bulk defect density has limited the use of β-SiC films in electronic devices. While several researchers have reported results relating the morphology of β-SiC films to deposition parameters, including substrate temperature and gas composition, detailed knowledge of the effects of deposition parameters on film morphology and crystallographic texture is still lacking. If these relationships between deposition parameters and film morphology can be quantified, then it may be possible to obtain optimal β-SiC film morphologies via CVD for specific applications such as high-power electronic devices.

The purpose of this study is to predict the dependence of the surface morphology of β-SiC films grown by CVD on substrate temperature and inlet atom ratio of Si:C, and to model the morphological evolution of the growing polycrystalline film. The Si:C ratio is determined by the composition of the reactant gases, propane (C_3H_8) and silane (SiH_4). A two-dimensional numerical model based on growth rate parameters has been developed to predict the evolution of the surface morphology. The model calculates the texture, surface roughness, and grain size of continuous polycrystalline β-SiC films resulting from growth competition between nucleated seed crystals of known orientation. Crystals with the fastest growth direction perpendicular to the substrate surface are allowed to overgrow all other crystal orientations. When a continuous polycrystalline film is formed, the facet orientations of crystals are represented on the surface. In the model, the growth parameter, α_{2D}, the ratio of the growth rates of the {10} and {11} faces, determines the crystal shapes and, thus, the facet orientations of crystals. The growth rate parameter α_{2D} used in the model has been derived empirically from the textures of continuous β-SiC films reported in the literature.