Caractérisation par Microscope à Force Atomique (AFM) des propriétés électriques et mécaniques à l'échelle nanoscopique des composants de puissances SiC : nano SiC

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Abstract

This thesis has been dedicated to the characterization of silicon carbide (SiC) for the applications in power electronics. Our studies have been focused on the local structural and electrical properties of the polymorph 4H-SiC. Although 4H-SiC shows interesting properties for the application in power electronics (large band gap, large thermal conductivity, large breakdown voltage, …), it has certain disadvantages compared with silicon materials, as for example the lower electron mobility and the large trap density at the interface with the oxide layer SiO2, which is probably at the origin of reliability issues still under investigation.. The aim of this thesis is to control different techniques based on atomic force microscopy, especially Scanning Spreading Resistance Microscopy (SSRM) and conductive AFM (c-AFM), in order to study locally SiC wafers and metal–oxide–semiconductor field-effect transistors (MOSFETs) of commercially available devices. Thanks to these methods, the local topographic and electrical properties have been studied on surfaces of monocrystalline SiC samples. One of the important aspects has been to understand the link between the crystalline orientation of the surface and its electronic properties. The step bunching effect on the surface, related to the monocrystalline growth of the samples, results in terraces and risers of different orientation, where the development of a statistical modelisation has allowed to analyze locally the crystalline orientation of the steps ans highlight terraces witch different conduction characteristics. We have also studied the local electrical properties of cross sections of SiC based MOSFETs, by developing a methodology for the visualization of the SiC layers with different doping, both for the doping type and the doping level. We have shown that it is possible to distinguish the different zones constituting the MOSFET ad to determine the local effective doping, which ist still complicated to achieve with other techniques based on the chemical differences. In addition, the local anodic oxidation mechanism was studied during c-AFM characterizations