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n-type doping of diamond for electronics

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Diamond offers very interesting potential applications for high temperature, high frequency and high power electronics. In order to use it as an electronic grade material, the controls of its quality and its doping are necessary. As most of wide band-gap semiconductors, diamond suffers from an asymmetry in the control of its doping. While the p-type conductivity is easily achieved by using boron impurities, the n-type doping is still an issue for the development of bipolar electronics based on diamond. As electronic applications need high material chemical purity, the microwave plasma assisted chemical vapor deposition (MPCVD) is currently the most used growth techniques for diamond. For n-type doping, the range of impurities that should fit into the diamond lattice is limited and the equilibrium solubility of dopants in bulk diamond is often low. Despite a covalent radius ~1.4 times bigger than carbon and a donor level relatively deep (EC=0.6eV), the highest n-type conductivities have been achieved with incorporation of phosphorus impurities during the homoepitaxial growth. This impurity has been reproducibly incorporated into (111) mono-crystalline diamond by using different phosphorus precursors (gaseous or liquid) during MPCVD diamond growth up to a few 1020 P/cm^3. However to incorporate phosphorus in donor sites is more difficult (100) orientation that is preferential for electronics. In this review, the difficulties inherent to the n-type doping of diamond will be presented. The different donors in diamond will be reviewed as well as the doping methods. The properties of n-type diamond grown in the GEMaC laboratory with phosphorus doping will be shown. The results achieved both on the (111) and the (100) orientated-substrates used for the homoepitaxy will be given. The incorporation in substitutional site and the high compensation level by residual impurities and defects will be discussed.

Biography

Marie-Amandine Pinault-Thaury is a Researcher of the French National Center for Scientific Research (CNRS), working at the “Groupe d’etude de la Matiere condensee” (GEMaC) laboratory. She is the Co-Head of the Diamond for Electronics group and In-Charge of the CAMECA-IMS7f equipment, a secondary ion mass spectrometer (SIMS). She is an expert in epitaxy and physical study of semiconductors.

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