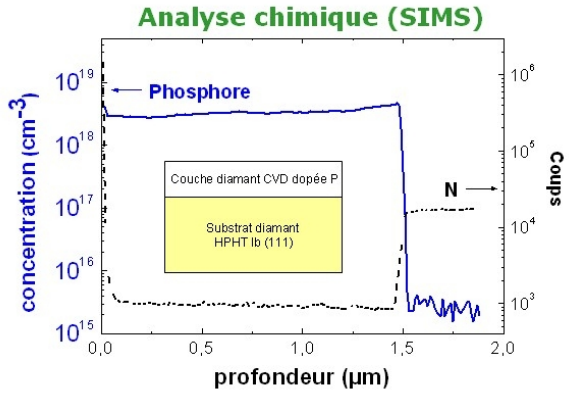
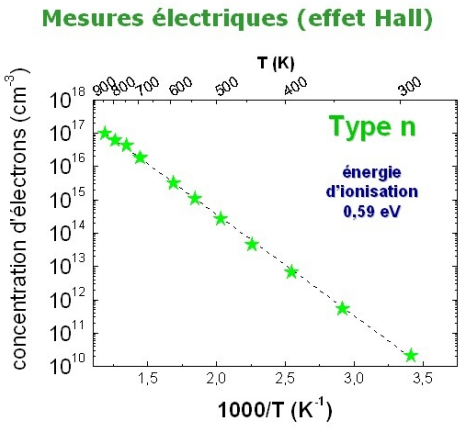
GEMaC

Groupe d'Étude de la Matière Condensée

PHOSPHORUS DOPED DIAMOND

Phosphorus doped diamond is synthetized in the team for its n-type electrical transport properties. Phosphorus is indeed the only chemical element that gives significant electron conductivities, when inserted in substitution of carbon. For this research topic, we have developed a new generation of diamond epitaxy reactor using, for doping, the technology of organometallic precursors from the III-V semiconductor industry (lasers, LEDs, ...).





Our goal is to find growth conditions where phosphorus atoms effectively contribute to the electrical conduction in the diamond layer. In practice, there are several phenomena that prevent the excess electron of phosphorus from being transferred to the diamond's conduction band:

» capture of the electron by an acceptor center: phenomenon of compensation by unintentional defects.

» sharing of the electron in a chemical bond with a neighbouring defect: complexes of the donor with a carbon vacancy, an interstitial hydrogen atom, ...

As a consequence, the electrical activity of the phosphorus donor is often far from 100% in diamond. The spectroscopy of bound excitons, performed by cathodoluminescence in the team, allows today to measure the concentrations of substitutional dopants in diamond with an unrivalled detection limit (0.05 ppb). Associated with infrared absorption measurements, these optical spectroscopies are used to evaluate the electrical activity of phosphorus in diamond and to optimize growth conditions.

Thanks to this strategy combining synthesis and spectroscopy, our phosphorus-doped diamond layers have had n-type conductivity at the state of the art since 2006 for homoepitaxial layers on the (111) orientation. More difficult on the (100) orientation, yet preferred in electronics, a narrow window of growth conditions was identified in 2012. Today, research is focused on the (113) orientation, which is intermediate and promising. It will be a question of exploiting the properties of n-type diamond obtained on these different crystal orientations in original architectures of electronic devices.