SEMINAR

Department of Functional Materials

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M. Bouras*, R. Gillet, F. Jomard, I. Stenger, T. Kociniewski, J. Barjon and M.-A. Pinault. Thaury

Groupe d'Etude de la Matière Condensée (GEMaC), Université de Versailles St-Quentin-En-Yvelines (UVSQ), Versailles - France

Ohmic contacts on ultra-lightly phosphorus doped (100) diamond

With the exponential technological development achieved in microelectronics and optoelectronics branch last decades, diamond became one of the most attractive semiconductors with regard to its advantageous functional properties, such as its wide bandgap energy, high breakdown voltage, high carrier mobility, unrivalled thermal conductivity, robustness, etc. Undoubtedly, the major advances made in microelectronics field is accompanied with growing requirements in terms of power consumption, high voltages resilient materials, high frequency processing, nanoscale size integration on chip, etc. Consequently, a good control of diamond structural and electronic properties, by means of more developed layers growth techniques, is needed.

Thus far, diamond layers growth has mainly been successfully achieved by Microwave Plasma Assisted Chemical Vapor Deposition (MPCVD). On the other hand, in order to exploit the benefits of diamond as a semiconductor in electronics domain, the control of both p-type and n-type doping is required. As boron is a natural doping element of diamond, todays the control of p-type diamond is well established. Unlikely, for its counterpart the n-type doping, performed so far only by phosphorus incorporation, it has not yet been controlled to a satisfactory level for a commercial use. Therefore, growing n-type phosphorus doped diamond layers with good crystalline quality and hence well controlled physical properties still remains a hurdle for unleashing the great potential of diamond in many applications.

For many electronic applications manufacturing a semiconductor with high charge carrier mobility would be a very exciting achievement, since it allows the conception of electronic devices with high frequency processing and less power consumption. Up to now, the record diamond electron mobility at room temperature is of 1060 cm^2/V.s. and has been reported on (111)-oriented layers doped with phosphorus concentration of [P] = $2x10^{15}$ $at.cm^{-3}$ [1]. However, based on the reported carrier mobilities for both p-type and n-type diamond as à function of doping levels [1-5], it is believed that the (100) orientation would present higher carrier mobilities compared to the (111) orientation. Furthermore, (100) orientation is preferred for electronics. Therefore, manufacturing (100) diamond layers would be a real headway for the conception of devices.

In this frame, we grow ultra-lightly phosphorus (100) oriented MPCVD diamond layers with [P] in the range of 10^{15} at/cm^3 and thicknesses between 6 to 7 µm. In order to assess the electronic features of such layers, Hall effect technique with high temperature and high impedance is the most suitable tool to access resistivity, mobility, carrier concentration, activation energy and compensation rate in dimaond. However, this technique requires the realization of electrical contacts that manifest an Ohmic behaviour. This point is a real challenge for n-type diamond as conventional metallic contacts are not efficient. With the ultra-lightly doping rate of the layers, this mission is even more challenging. We will present the specific protocols developed in GEMaC to achieve ohmic contacts on (100) phosphorus-doped diamond homoepilayers.

References

1. H. Kato et al, Appl. Phys. Lett. 109 (2016), **2.** H. Kato et al, Mater. Res. Soc. Symp. Proc. 1039 (2008), **3.** S. Yamanaka et al, Jpn. J. Appl. Phys. 37 (1998), **4.** P-N. Volpe et al, Diam. Relat. Mater. 94 (2009), **5.** C. Tavares et al, Appl. Phys. Lett. 15 (2006).

Dr M. BOURAS is a Post-Doctoral Research Associate working in Groupe d'Etude de la Matière Condensée (GEMaC), France, in the Diamond for Electronics group of Prof. Julien Barjon and Dr. M.-A. Pinault-Thaury Senior Research Fellow. His current research interest is the synthesis of n-type doped diamond and study of the physical properties of thin layers of phosphorus-doped diamond.