NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2023-2024

Electrical characterization of diamond diodes for application in power electronic or high frequency

General Scope :
Diamond is a semiconductor material with exceptional properties, like its high carrier mobility, excellent thermal conductivity and high breakdown voltage, which make it an ideal candidate for power electronic devices. Institut Neel is world leader in the fabrication of high-power diamond Schottky diodes and is continuously exploring ways for further improvements.

Research topic and facilities available :
The Schottky potential barrier, formed at the junction between a metal and a semiconductor, is highly advantageous for rapid switching and maintaining a low voltage drop in the forward bias region. In the construction of Schottky diodes using diamond as the semiconductor material, our approach involves depositing a metal electrode onto a surface of oxygen-terminated or OH-terminated p-type (boron-doped) semiconducting diamond epilayer. This epilayer is situated atop a metallic ("p++") diamond epilayer, serving as the back contact, resulting in the creation of a vertical structure. Our primary research focus has been on optimizing metal-diamond interfaces to achieve rectifying behavior. We have demonstrated that zirconium (Zr) [1], a metal susceptible to oxidation, is an exceptional candidate for efficiently forming Schottky barriers. Unfortunately, the current leakage in the reverse bias region remains unacceptably high for power applications. Additionally, the restricted size of the contact presents challenges in achieving high forward bias current [2].
To address these challenges, our team at the Neel Institute, specializing in wide bandgap semiconductors, has recently explored an innovative growth approach. This approach involves growing thin diamond layers doped with a nitrogen layer (n-type) prior to Schottky metal deposition. The underlying concept is to induce a reverse band bending effect distinct from that of the p-type layer, which should enhance the barrier for holes. Simultaneously, efforts have been directed towards optimizing diamond growth to increase the dimensions of the diamond substrate and enhance the diode's current-carrying capacity.

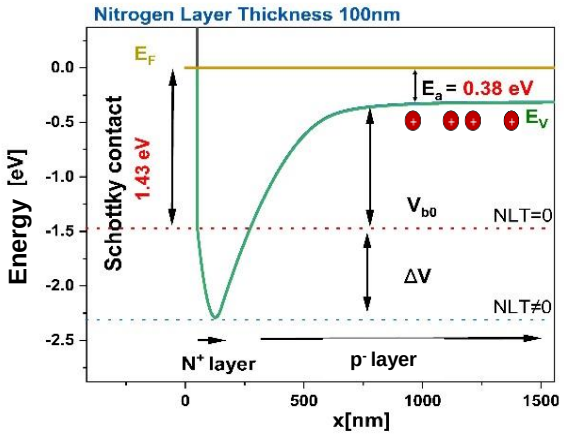

Figure 1 : Numerical modelling of Schottky contact on p-type diamond layer with a thin intermediate nitrogen layer

The assigned student will be responsible for characterizing various diamond components that have already been grown using a range of electrical techniques, including current-voltage and capacitance-voltage-frequency measurements. Additionally, the influence of temperature, a critical parameter for the power application of diamond diodes, will be examined [3]. Depending on the timeframe, the student

may also participate in the diamond growth process to expand the surface area available for experimentation and application.

1. Traoré, A. *et al.* Zr/oxidized diamond interface for high power Schottky diodes. *Appl. Phys. Lett.* **104**, (2014).
2. Eon, D. & Cañas, J. General optimization of breakdown voltage and resistivity on power components in terms of doping level and thickness. *Diam. Relat. Mater.* **136**, 110032 (2023).
3. EON, D. Self-heating in a diamond Schottky diode influenced by U-shaped resistivity. *Diam. Relat. Mater.* **130**, 109414 (2022).

Possible collaboration and networking :
The student will interact with engineers of Diamfab a startup hosted by the laboratory.

Possible extension as a PhD :
According to the classification of the candidate a continuation of the project in thesis is possible

Required skills:
Any master in physics or electronic engineering with minimum knowledge in semiconductor physics.

Starting date : February 2024

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