CIFRE PhD program proposal:

Radiation reliability of diamond semiconductor devices for automotive, nuclear, and space environments

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Energetic particles can jeopardize the proper behavior of electronic components in a variety of application fields: cosmic rays can affect space-bound electronics, causing frequent malfunctions if left unmitigated; neutrons and gamma rays in nuclear power plants can lead to premature aging of the circuits; even at sea level on Earth, natural radioactivity can cause rare, but potentially catastrophic failures if humans lives are at stake, for instance in automotive applications. As a result, radiation qualification and hardening – i.e., avoiding and mitigating such issues – is a vital part of electronics reliability, and should be researched for emerging technologies whose physical behavior is not yet fully understood.

In particular, diamond semiconductor devices are regarded as promising future components for applications requiring high power or high temperature, potentially outclassing existing wide bandgap materials such as gallium nitride (GaN) or silicon carbide (SiC) that are already replacing silicon-based components in several applications. Radiation effects in power devices can be catastrophic, with a single particle sometimes causing complete destruction of the component due to high voltage, current, or temperature stress within the device. As a result, GaN and SiC have received growing interest from the radiation effects community recently, but to this day, next-gen diamond-based devices have barely been studied under radiation.

Therefore, the goal of this PhD program will be to prospect the radiation hardness of diamond devices (including diodes and transistors manufacted by Diamfab, an SME based in Grenoble, France), both by simulation and experimental means:

- Physical and electrical characterizations will be performed on components exposed to various radiation stresses, namely radioactive sources such as alpha-ray emitters available in the lab, or particle beams available at external particle accelerator facilities.
- Simulation and modeling tools will be used to further investigate the mechanisms at play: Monte Carlo nuclear codes such as Geant4 (CERN) will be employed to capture the initial energy deposition of particle trajectories inside the semiconductor material; technology computer-aided design (TCAD) tools such as Sentaurus (Synopsys), i.e. semiconductor physics simulators, will also be put to use understand the charge transport mechanisms responsible for radiation failures inside the irradiated devices.
- In light of the results, the PhD will also project an outlook on challenging automotive / nuclear / space mission profiles where diamond can reliably operate.

This thesis program will be setup as a three-year CIFRE industrial PhD, supervised by STMicroelectronics (Crolles site, Grenoble area, France) and laboratoire Ampère (Lyon, France). The student will be based mainly in ST Crolles – joining an R&D team focused on radiation effects and electronics safety – and will tightly interact with Ampère lab, who have a strong expertise in power components. Applicants should hold an MSc (or equivalent, e.g. French engineering school) in physics or electrical engineering, with a focus on semiconductor physics and/or electronics. Knowledge of radiation physics is appreciated, but not necessary.