Second harmonic generation for semiconductor materials and interfaces characterization

Deadline for application: the 1st of July 2019, beginning of contract: the 1st of Oct. 2019

Place: **IMEP – LAHC, MINATEC – INPG, 3, Parvis Louis Néel, 38016, Grenoble**
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Context:
This PhD topic is financed within the French national plan Nano 2022, which is a part of the European project IPCEI "Nanoelectronics for Europe" and has the aims to support micro/nanoelectronics industry. Among its 5 strategic axes, smart sensors (such as the image sensors) occupy an important place. The improvement in performances of such devices requires continuous technological optimizations of the materials and interfaces constituting them. Most of the times, the materials used are thin film layers (or stacks containing multiple thin films) and their non-destructive, full-wafer characterization is really challenging.

PhD objectives and work-to-do:
The objective of this PhD is to develop an innovative characterization method for multi-layers of high-k dielectrics used for silicon passivation. The method uses the second-harmonic generation (SHG), which is a non-linear optics phenomenon. The particularity of the SHG generated by centrosymmetric materials (such as Si, Al_2O_3, HfO_2…) is that the signal, mainly coming from interfaces' contributions, is very sensitive to the electrical field present there. For image sensors, both high interface quality and field-effect passivation are required and both of them can actually be measured by the SHG[1]. These objectives require two key elements to be handled in the PhD: (1) deconvolution of optical propagation phenomena in order to access electrical properties of the interface and (2) calibration of the SHG using other electrical measurements such as capacitance versus voltage on structures specifically fabricated in clean-room. The topic is therefore multidisciplinary (semiconductor physics, semiconductor device physics, non-linear optics …) and convers the full spectrum from simple test-structures fabrication, to SHG measurements and modeling and to electrical characterization and parameters extraction.

Scientific environment and collaborations:
The PhD student will benefit from innovative **equipment: a unique prototype in Europe**, installed at IMEP-LAHC in 2014. Additionally, we developed a **home-made optical simulator** in order to explain the experimental results. The student will also benefit from samples of high interest to the imaging sensors, from STMicroelectronics. The topic is thus strongly connected to both **academic and industrial** world, since it covers the physical understanding and the pragmatic applications for microelectronics.

Knowledge and skills required:
This Ph.D. topic belongs to the micro-nano-electronics field but it is multidisciplinary (non-linear-optics, electrical characterization and modeling of semiconductor-dielectric interfaces). The candidate must have a solid knowledge in at least one of these fields. Her/his scientific curiosity and open-mindedness should allow her/him to acquire the other technical skills. The candidate is expected to enjoy both experimental and simulation work. Scientific curiosity and rigor, motivation, seriousness and creativity are mandatory qualities in order to take full advantage of the scientific environment of this thesis and to gain excellent expertise for her/his future career. The topic is close to both fundamental physics and industrial world; after the Ph.D. the candidate should be able to easily adapt to both academic and industrial research environments.

The candidate must have a very good academic record, with high grades.

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[1] M.L. Alles et al, IEEE Transactions on Semiconductor Manufacturing, vol. 20, 107 (2007)
D. Damianos et al, Solid State Electronics, vol. 115, p.237, 2016