Surface Passivation Characterization of InP probed by High Frequency Modulated Photoluminescence and Time Resolved Photoluminescence

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III-V semi-conductors are recognized as high-performance materials for the fabrication of (opto)electronics devices such as avalanche photodiodes, light emitting diodes and lasers. For many years, Indium Phosphide (InP) based thin film III-V emitters ($Ga_xIn_{1-x}P$ and $Ga_xIn_{1-x}As_yP_{1-y}$) are commonly used by the optoelectronics industries. Numerous passivation techniques have been developed to improve the surface properties of InP. Among those, the passivation by an ultra-thin film of polyphosphazene is expected to be efficient and stable in time. However, unawareness of the physics on these materials can prevent promoting the overall performances of the passivated layers/devices. In this case, advanced contactless photoluminescence characterization methods are proved to be powerful to determine carriers' dynamics and recombination mechanisms.

One classical method called Time Resolved Photoluminescence (TRPL) has been commonly used for probing fast recombination mechanisms under the nanosecond regime in thin film semi-conductors. The interpretation of the TRPL temporal decays may be difficult when presenting non mono-exponential behaviour. In order to provide complementary information, another approach, which is called High-Frequency Modulated Photoluminescence (HF-MPL) can also be used to investigate carrier lifetime by using sinusoidal illumination variation and recording the phase shift between the excitation signal and emitted signal [1] HF-MPL can be closer to the real excitation conditions and enable to focus on slow mechanisms such as carrier trapping and surface recombination. We upgraded this method by extending the modulation frequency range up to 100 MHz, so that it can examine fast carriers' dynamics while keeping high sensitivity.

In the main part of this work, TRPL and HF-MPL technique are used on n type InP with two different doping, passivated by an ultra-thin film of polyphosphazene obtained in liquid ammonia, synthesized by Institut Lavoisier de Versailles [2]. Comparison is made with non-passivated samples prior and after desoxidation. The passivation seems to prevent degradation as a function of time and the surface is modified. The impact of the passivation on the transport properties is currently investigated by spatially resolved PL.

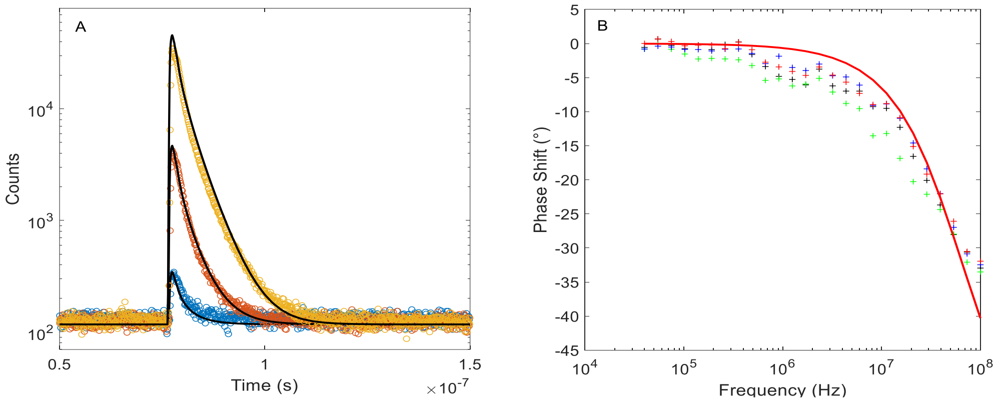

Figure 1. A: TRPL decays measured on a highly doped (3 x 10^{18} cm^{-3}) phosphazene passivated InP sample. Illumination power correspond to 10^{10} photons/pulse/cm^2 times 1(blue), 20 (red), 200 (yellow). Solid black lines correspond to a fit with one-dimensional drift diffusion model. B: HF-MPL data recorded on the same sample at mean flux 10^{17} photons/cm^2/s times 10(black), 100(green), 1000 (blue), 10^4 (red). Solid lines correspond to a fit with the same model as TRPL.

[1] B. Bérenguier *et al.*, "Defects characterization in thin films photovoltaics materials by correlated high-frequency modulated and time resolved photoluminescence: An application to Cu(In,Ga)Se_2," *Thin Solid Films*, Nov. 2018.

[2] A.-M. Gonçalves, C. Njel, C. Mathieu, D. Aureau, and A. Etcheberry, "Phosphazene like film formation on InP in liquid ammonia (223K)," *Thin Solid Films*, vol. 538, pp. 21–24, Jul. 2013.