GROWTH OF CRYSTALLINE III-V THIN FILMS USING LOW-TEMPERATURE PLASMA

Karim Ouaras[1,*], Lakshman Srinivasan[1,2], Jean-Luc Maurice[1], Cyril Jadaud[1], Jean-Charles Vanel[1], Pere Roca I Cabarrocas[1,2]

[1]LPICM, CNRS, Ecole polytechnique, Institut polytechnique de Paris 91120 Palaiseau. France.

[2]IPVF -Institut Photovoltaïque d'Ile-de-France, 18 Bd Thomas Gobert, 91120 Palaiseau, France.
[*]karim.ouaras@polytechnique.edu

Keywords: III-V materials, crystalline thin films, GaN, plasma, physical vapor deposition

The semiconductor (SD) industry has to face increasingly challenging, complex, and performant device requirements in response to the growing demand on solar energy, electrical vehicles, consumer electronics, sensors, lighting, Internet of Things (IoT) and emerging sectors such as block-chain technology (web 3.0, metaverse …). Meanwhile, the economic and social crisis that we are going through asks for the quick development of cheaper, less energy consuming, and eco-friendly semiconductor-based devices. In the immediate future, the driving force for research is clear: we have to find alternative SD fabrication processes that meet these requirements and to use them for producing materials (*e.g.* GaN) that outperform silicon that still currently rules the industry but whose performances have now reach their limits. Even though current crystal growth processes such as Metalorganic Chemical Vapor Deposition (MOCVD) and Molecular Beam Epitaxy (MBE) provide a solution for the production of modern SD devices, they still face big challenges in terms of device reliability, and those processes definitively raise environmental and economic issues. Indeed, they usually operate with complex and expensive set-ups and/or make use of high quantity of expansive and toxic gases. In addition, they work at high temperature, typically stronger than 800 °C for most common SD deposition, which induces thermal expansion issues when the growth of hetero-structure is targeted, leading to defects at the interface.

The use of a plasma, especially in Physical Vapor Deposition (PVD) mode, offers a promising way to overcome the challenging issues experienced by the other methods mentioned earlier. Indeed, the application of an electric field brings the energy to the electrons to enhance the reactivity of the gas to create a highly reactive media made of ions, excited species, radicals and nanoparticles, while keeping a (gas) temperature ranging from Room Temperature (RT) to ~200 °C, so mitigating the risk of thermal mismatch issues. Apart from those features that make plasma processes unique, in PVD mode, the use of a target made of the material of interest in front of a plasma enables the synthesis of thin films of same nature as the target and the dissociated gas, without resorting to costly or toxic gases.

At LPICM, we have developed a new axis of research dedicated to the growth of Gallium based material (*i.e.* GaN and GaAs) using low-pressure plasmas. As a first step, a Gallium target exposed to an Ar/N_2 plasma has been used here to produce thin films made of GaN. In this presentation, we will give an overview of the preliminary and recent results showing the growth of polycrystalline GaN deposited on Silicon at room temperature (see Figure 1).

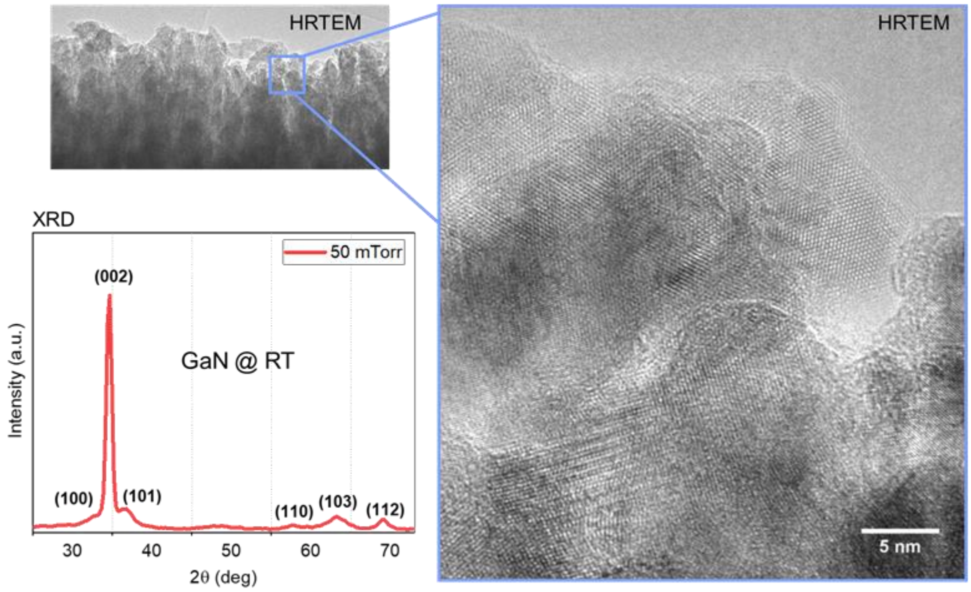

Figure 1. Recent results showing high-resolution transmission electron microscopy (HRTEM) and X-ray diffraction pattern (XRD) of a polycrystalline GaN film grown at room temperature in Ar/N_2 PVD plasma reactor.