Study of $PtSe_2$ synthesis by molecular beam epitaxy for high frequency optoelectronics

Eva Desgué
Pierre Legagneux, Delphine Pommier, Doriane Jussey
THALES Research & Technology, 1 av. Augustin Fresnel, Palaiseau, France
eva.desgue@thalesgroup.com

$PtSe_2$ is a 2D material with high intrinsic qualities suitable for high frequency IR optoelectronics [1], especially for photodetection at the 1.55µm telecom wavelength. We investigated the synthesis of $PtSe_2$ thin films on sapphire substrates by molecular beam epitaxy. In particular, we studied the impact of a post-growth annealing for various Se fluxes on the full width at half maximum (FWHM) of the $PtSe_2$ E_g Raman peak (Fig.1): a small E_g FWHM value means a high crystallinity [2], essential for good (opto)electronic performances. We also grown $PtSe_2$ on vicinal sapphire(0001) surfaces and demonstrated an improvement of film crystallinity and electronic mobility. We characterized the films using grazing incidence X-ray diffraction (GIXRD) and transmission electron microscopy (TEM). To fabricate optoelectronic devices, we synthesized a 7.5nm-thick $PtSe_2$ film on a 2 inches sapphire substrate and coplanar waveguides integrating a 4x4 µm $PtSe_2$ channel were then realized. The channel was illuminated with a 1.55µm laser beam modulated in intensity at frequencies varying between 2 and 67 GHz. Our $PtSe_2$ photodetector exhibits a record 3dB bandwidth of 60GHz (Fig. 2). Moreover, we demonstrated a 30GHz bandwidth optoelectronic mixer, comparable to those obtained with graphene [3]. These results confirm that $PtSe_2$ is a highly promising material for high frequency optoelectronics.

References

[1] Y. Wang et al., Appl. Phys. Lett., 116 (2020), 211101
[2] S. Lukas et al., Adv. Funct. Mater., 31 (2021), 2102929
[3] L. Hamidouche et al., ACS Photonics, 8 (2021), 369

Figures

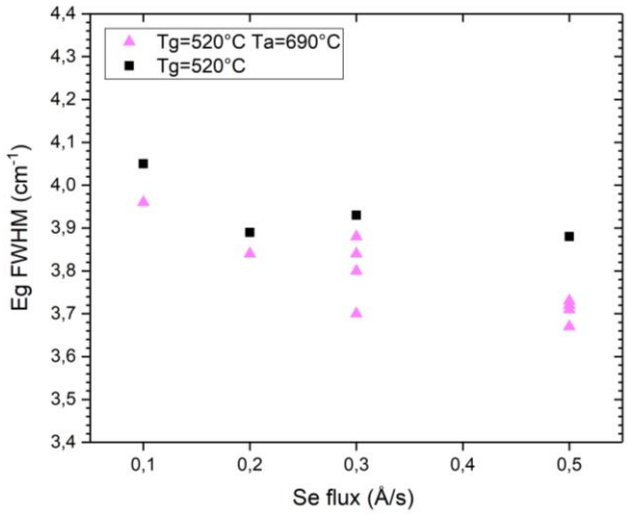

Figure 1: FWHM of Eg RAMAN peak of $PtSe_2$ films grown at Tg=520°C with a post-growth annealing at Ta=690°C (purple triangles) or without anneal step (black squares), under different Se fluxes.

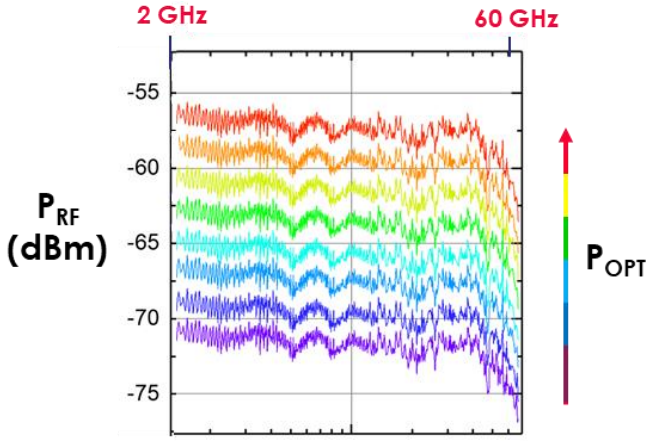

Figure 2: High frequency 1.55µm photodetection with a 7.5nm-thick $PtSe_2$ channel inserted in a coplanar waveguide. A 60GHz bandwidth photodetector is demonstrated.