

PtSe₂ films grown by molecular beam epitaxy for high frequency optoelectronics

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PtSe₂ is a 2D material with high intrinsic qualities suitable for high frequency IR optoelectronics [1], exhibiting a bandgap varying from 1.2eV (monolayer) to 0.2eV (bilayer) and becoming semi-metallic for few layers and in bulk form [2]. We investigated the synthesis of PtSe₂ 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 PtSe₂ Eg Raman peak (Figure1): thinner is the Eg peak width, higher is the crystalline quality [3] which is essential for high (opto)electronic performances. PtSe₂ was also grown on vicinal sapphire(0001) surfaces and we demonstrated a large improvement of film crystallinity using grazing incidence X-ray diffraction (GIXRD) and transmission electron microscopy (TEM) techniques. Conductivity and carrier mobility measured by Van der Pauw experiments on 20x20 mm samples are also improved.

We synthesized a 7.5nm-thick PtSe₂ film on a 2 inches sapphire substrate and fabricated coplanar waveguides integrating a 4x4 μm PtSe₂ channel. The channel was illuminated with a 1.55μm laser beam modulated in intensity at frequencies varying between 2 and 67 GHz. Our PtSe₂ photodetector exhibits a record 3dB bandwidth of 60GHz (Figure 2).

References

- [1] Y. Wang et al., Appl. Phys. Lett., 116 (2020), 211101
- [2] Y. Wang et al., Nano Lett. 15 (2015), 4013
- [3] S. Lukas et al., Adv. Funct. Mater., 31 (2021), 2102929

Figures

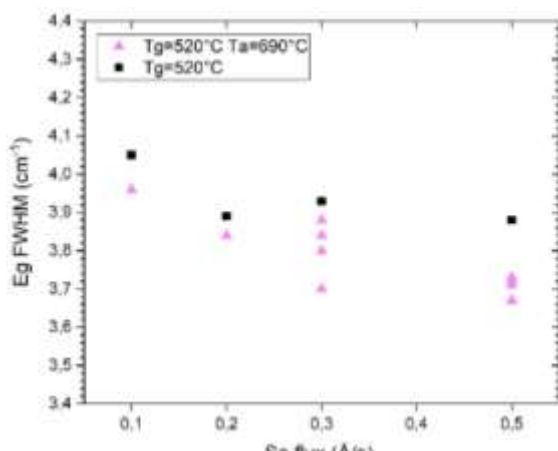


Figure 1: FWHM of Eg RAMAN peak of PtSe₂ films grown at T_g=520°C with a post-growth annealing at T_a=690°C (purple triangles) or without annealing step (black squares), under different Se fluxes.

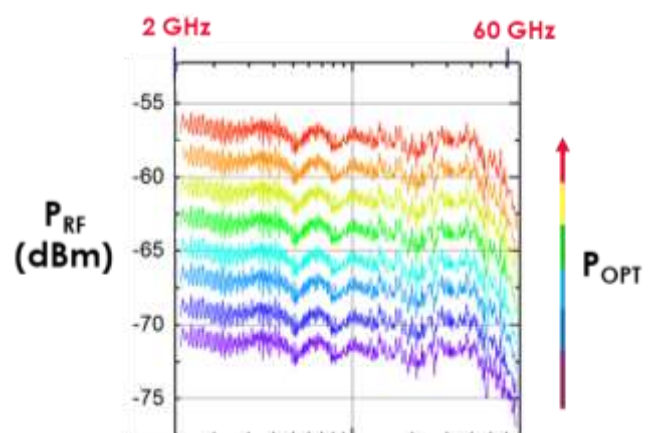


Figure 2: High frequency 1.55μm photodetection with a 7.5nm-thick PtSe₂ channel inserted in a coplanar waveguide. A 60GHz bandwidth photodetector is demonstrated.