Synthesis of $PtSe_2$ by molecular beam epitaxy for 60 GHz bandwidth 1.55 µm photodetectors

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$PtSe_2$ is a promising 2D material for high frequency IR photodetection [1], its bandgap varying from 1.2eV (monolayer) to 0.2eV (bilayer) [2]. We synthesized 2D $PtSe_2$ films on sapphire substrates by molecular beam epitaxy using simultaneous Pt and Se fluxes. In particular, we studied the impact of the Se flux for a growth temperature of 544°C with/without a post-growth anneal at 704°C on the full width at half maximum (FWHM) of the $PtSe_2$ E_g Raman peak. A small FWHM value is an indicator of crystallinity and electronic quality [3]. We also characterized the crystalline quality using XPS, grazing incidence X-ray diffraction and TEM.

We synthesized a 15 layers thick $PtSe_2$ film on a 2 inches sapphire substrate to fabricate (opto)electronic devices. In particular, coplanar waveguides integrating a 4x4 µm $PtSe_2$ channel were realized to perform high frequency photodetection. The channel was illuminated with a 1.55 µm laser beam modulated in intensity at frequencies varying between 2 and 60 GHz. Our $PtSe_2$ photodetector exhibits a record 3dB bandwidth of 60 GHz. These results show that $PtSe_2$ is a highly promising material for high frequency photodetection and should be evaluated for high frequency optoelectronic mixing [4].

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.
[4] L. Hamidouche et al. ACS Photonics 8 (2021), 369.

Figures

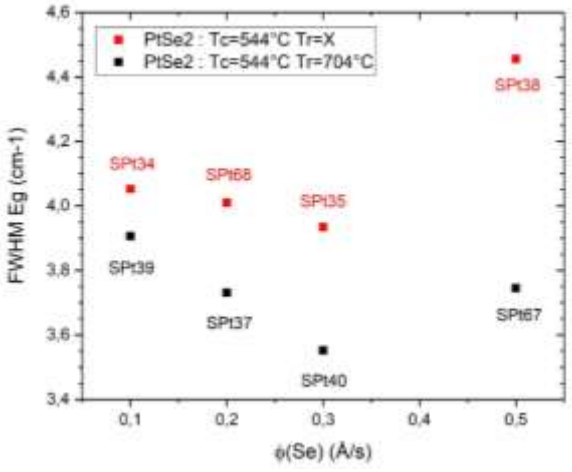

Figure 1: FWHM values of $PtSe_2$ E_g Raman peak for various growth conditions. A small FWHM value is an indicator of crystallinity and electronic quality [3]

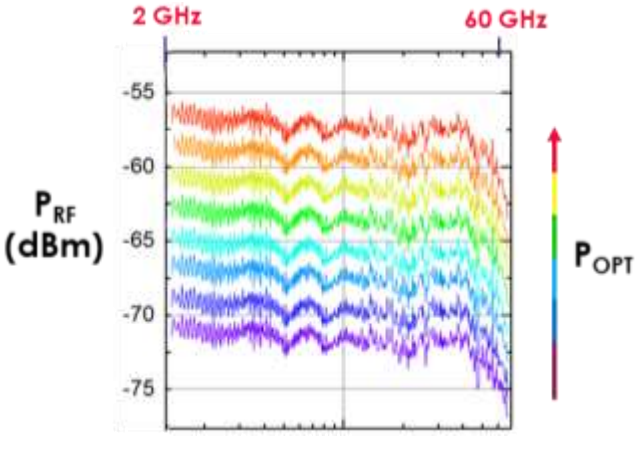

Figure 2: High frequency 1.55 µm photodetection measurements of a $PtSe_2$ channel inserted in a coplanar waveguide. A 60 GHz bandwidth is obtained