

Semimetallic PtSe₂ and PtTe₂ Films Grown by Molecular Beam Epitaxy for High Frequency Optoelectronics

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Multilayer PtSe₂ and PtTe₂ are original transition metal dichalcogenides exhibiting semimetallic behaviour and high electrical conductivity. We have studied the growth of these films on sapphire by molecular beam epitaxy, as well as their transport properties and their potential use for high frequency optoelectronics. 15 ML PtSe₂ exhibit a sheet conductance of up to 1.6 mS [1], which can be monitored through Raman metrics (see fig.1). These Raman metrics are the full width at half maximum (FWHM) of the in-plane E_g and the out-of-plane A_{1g} Raman peaks. The thinner the FWHM values, the higher the crystalline quality [1]; the lowest values are obtained for exfoliated PtSe₂ [2]. Fig. 1 shows a strong correlation between both E_g and A_{1g} FWHMs and sheet conductance for our MBE "Gen1" and "Gen2" films, as well as for films obtained by thermally assisted conversion (TAC) [3].

PtTe₂ films with a similar thickness exhibit a higher sheet conductance of over 6 mS, which increases with the growth temperature (see fig. 2). We will also present the correlations between E_g & A_{1g} FWHMs and the film conductivity for these PtTe₂ films.

Using 15 ML PtSe₂ grown on a 2-inch wafer, we demonstrated 60 GHz bandwidth photodetectors and 30 GHz optoelectronic mixers [1] operating at the telecom wavelength of 1.55 μ m (fig. 3). We will present a comparison of PtSe₂ and PtTe₂ based devices in terms of their photodetection and mixing performances. For graphene-based devices, higher carrier mobility leads to higher conductivity and photoconductivity [4]. These studies will determine if semimetallic films with higher conductivity also lead to higher optoelectronic performances.

References

- [1] E. Desgué *et al.*, arxiv.org/abs/2503.20659 (2025).
- [2] M. Tharrault *et al.*, 2024 2D Mater. 11 025011 (2024).
- [3] S. Lukas *et al.*, Adv. Funct. Mater. 2102929 (2021).
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Figures

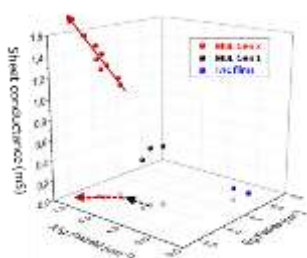


Figure 1: Sheet conductance of PtSe₂ films as a function of E_g and A_{1g} FWHMs. Graph includes TAC films [3] and our MBE films.

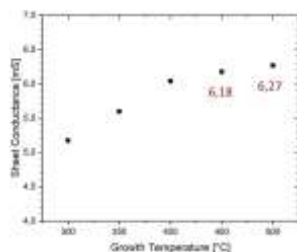


Figure 2: Sheet conductance of PtTe₂ films as a function of the growth temperature.

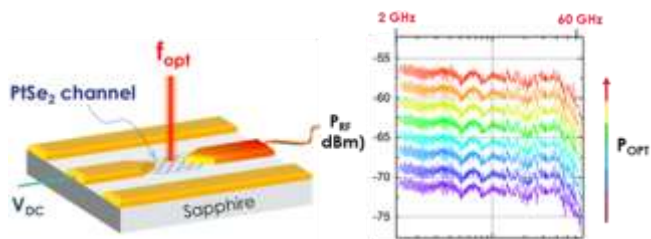


Figure 3: (Left) PtSe₂ based coplanar waveguide. A 1.55 μ m laser spot is focused on the PtSe₂ channel. V_{DC} = 4 V. The laser power is modulated at f_{opt} varying between 2 and 67 GHz. (Right) Photodetected power as a function of f_{opt} and optical power.