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SYNTHESIS AND CHARACTERIZATIONS OF 2D PLATINUM DISELENIDE

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Outline

- $PtSe_2$ notable features
- Practical directions
- Preparation stages
- Characterisations and experiments
- Conclusion
- Acknowledgments and Funding

$PtSe_2$ notable features

$PtSe_2$

- The parent material in TMDs noble element group
- Semiconductor in 2D form with bandgap 1.2-1.8 eV
- Overall semiconductor – semimetal properties vary depending on number of layers (thickness)
- Higher mobility of charge carriers

  comparable to Black Phosphorous

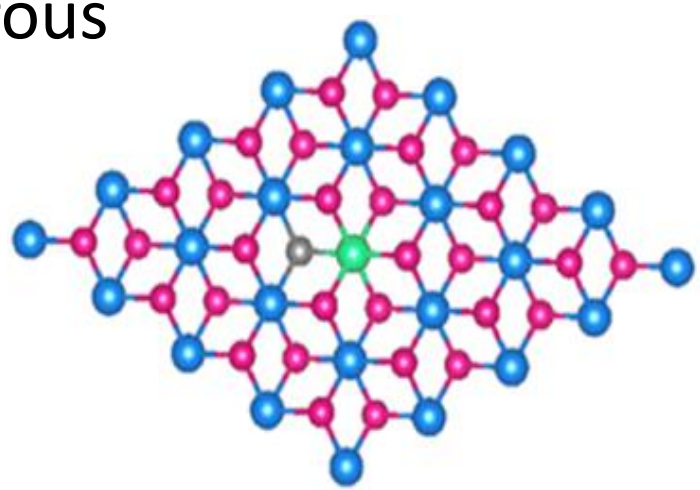

Fig. Molecular view of $PtSe_2$
AIP Advances **7**, 125126

Practical directions

- Environmentally stable
- Synthesis requirements are compatible with current industrial technologies
- Potential for optoelectronics
- Sensors & catalysis

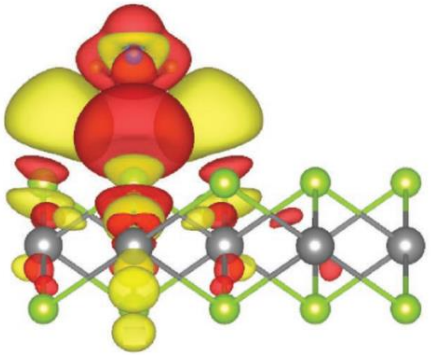

Fig. Charge density difference for H_2O adsorbed on monolayer $PtSe_2$
Adv. Mater. Interfaces **2017**, 1600911

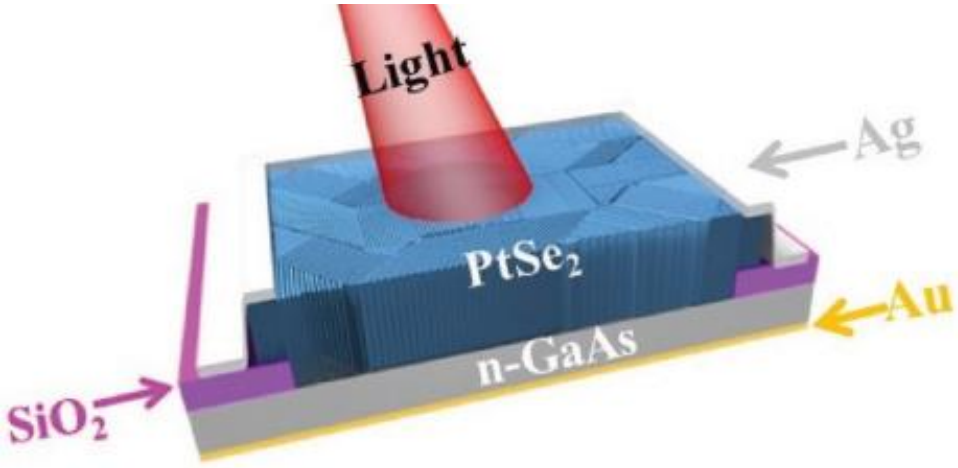

Fig. Schematic illustration of PtSe2/GaAs heterojunction based photodetector
Adv. Funct. Mater. **2018**, 1705970

Thermal assisted conversion (TAC) method

Stage 1

Pre-deposition of Pt film using a custom built magnetron sputtering system

Stage 2

A direct selenization of the pre-deposited films in a CVD reactor based on a dual zone tube furnace

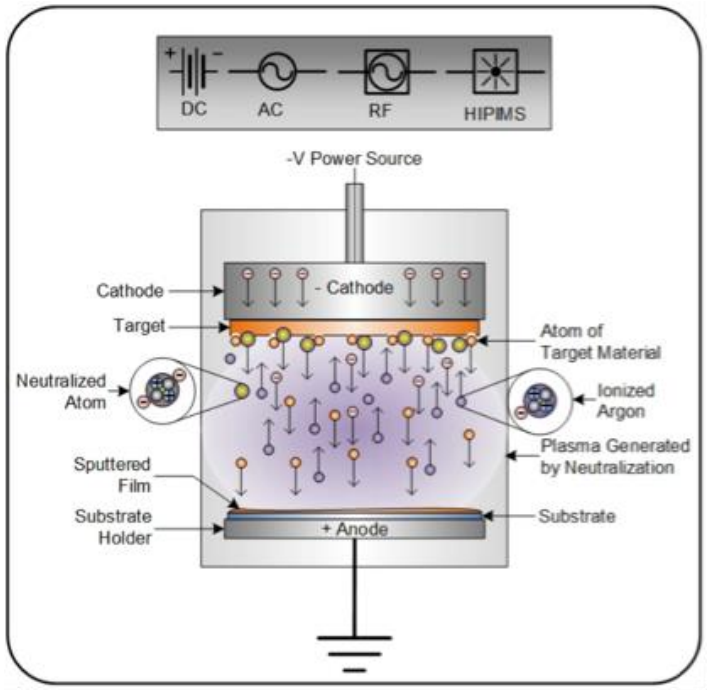

Fig. Magnetron spattering (charier-gas reactive conversion)

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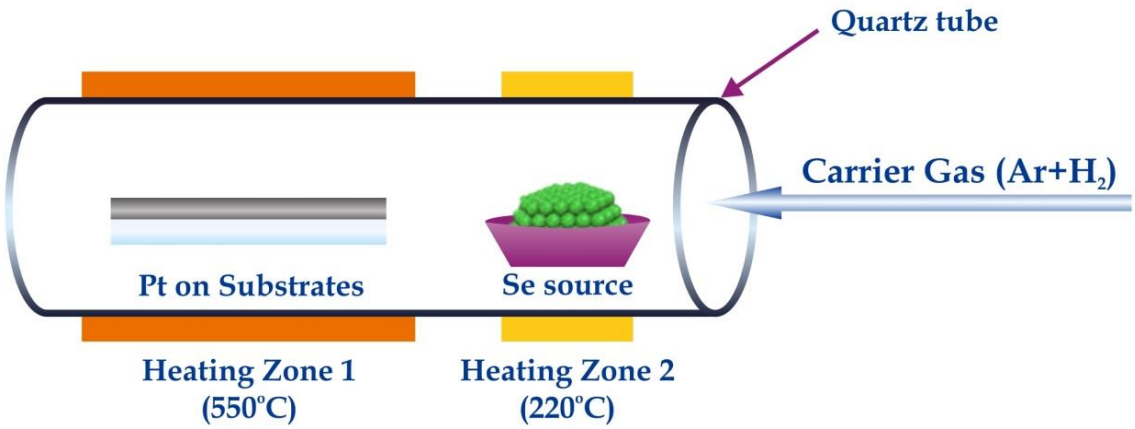
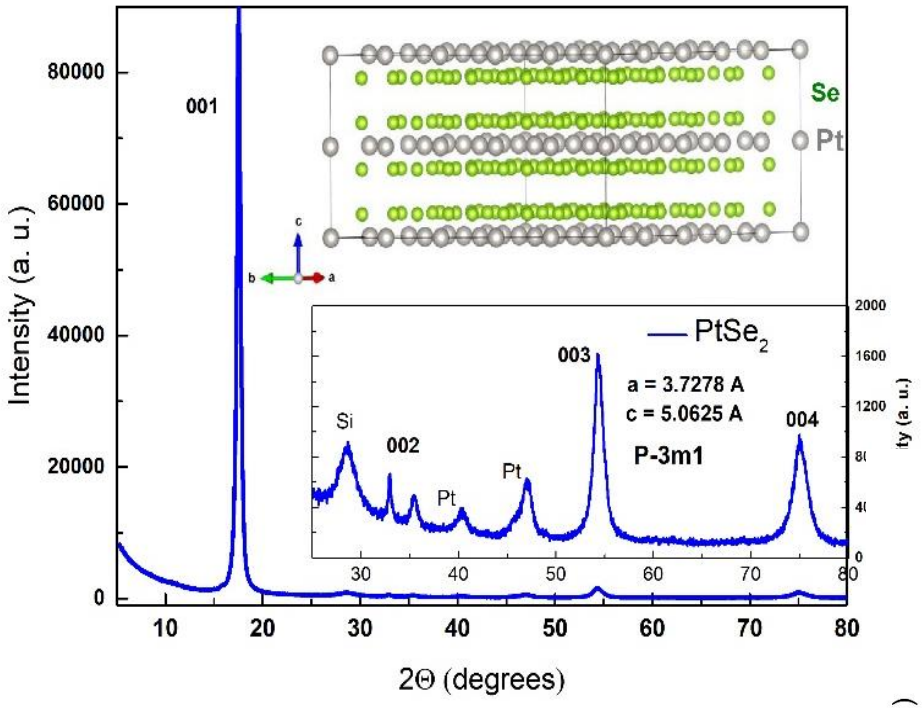


Fig. CVD selenization process

The CVD process is mediated via a carrier/reactive gas mixture flow of 95% Ar / 5% H_2 for 2h with consequent formation of another necessary gaseous precursor - H_2Se to enable the $PtSe_2$ growth.

Characterisations and experiments



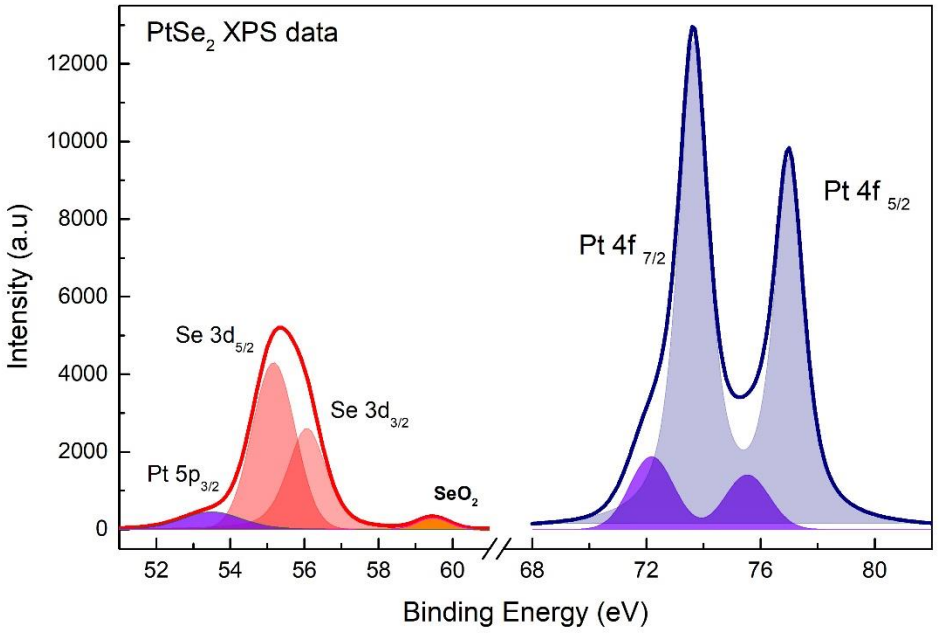
- **XRD analysis**

Hexagonal P3m1 [164] space group
Crystal lattice parameters:
a = 3.728 Å and c = 5.06 Å
c-axis growth
Highly oriented crystal structure 00l

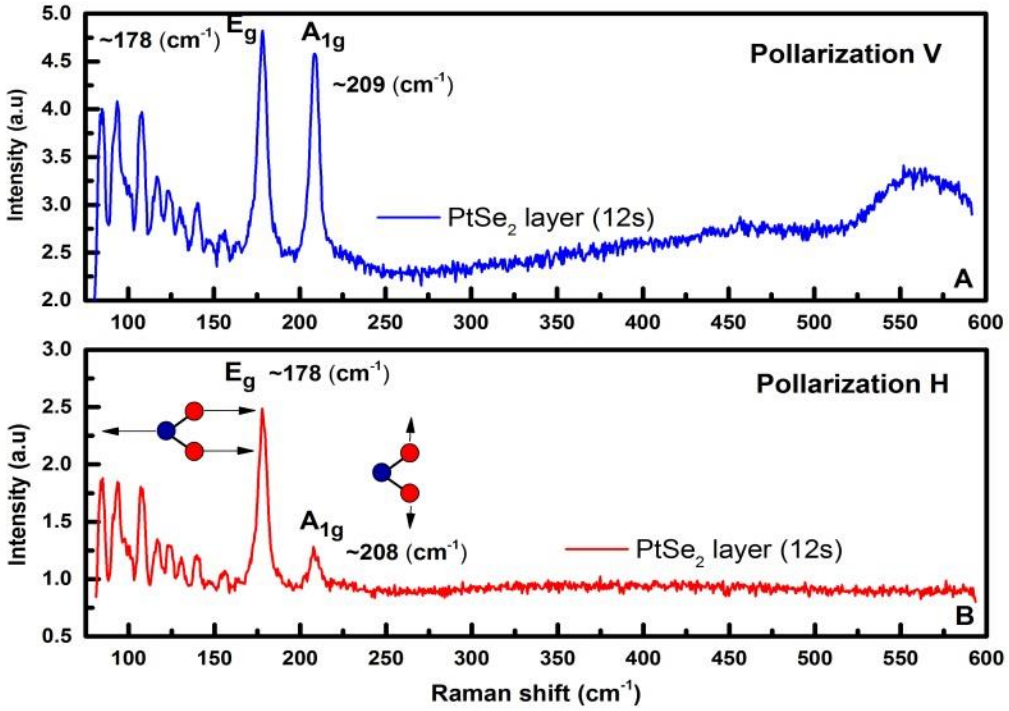
- **XPS analysis**

Indicating PtSe2 phase is successfully formed with spin-orbital splitting at 3.35eV:

Se 3d peaks:	Pt 4f peaks:
~55eV ($PtSe_2$)	~72.3eV (PtO)
~59.5eV (SeO)	~73.6eV ($PtSe_2$)



Characterisations and experiments

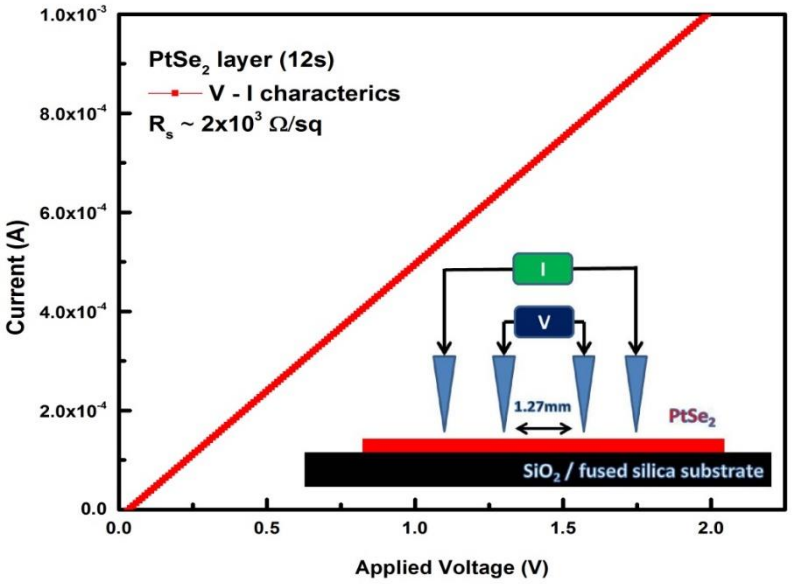


- **Raman spectroscopy**

The characteristic Raman active Eg (178 cm^{-1}) and A1g (208 cm^{-1}) mode of TAC deposited $PtSe_2$ confirm the composition and quality of the obtained samples.

- **Sheet resistance by four probe method**

V-A characteristics (Ohm contacts) and
R_s ~ 2x10^3 Ω/sq



Conclusions

- $PtSe_2$ was successfully synthesized by thermal assisted conversion process;
- Structural and chemical characterizations confirm the composition and crystalline quality of $PtSe_2$ (highly oriented crystal structure) ;
- The obtained results allow further directions for improvement of the deposition periods to facilitate the nanostructure synthesis approach towards $PtSe_2$ applications.

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