



Università
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2025 Fall Meeting

Effect of Post-Synthesis Treatments on 1L-MoS₂ Nanocomposite Properties

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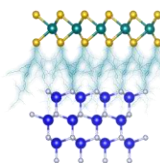
⁵CNR - Istituto Officina dei Materiali (IOM) – Trieste, Italy

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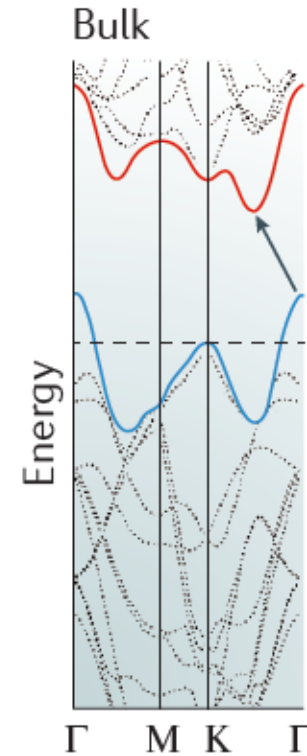
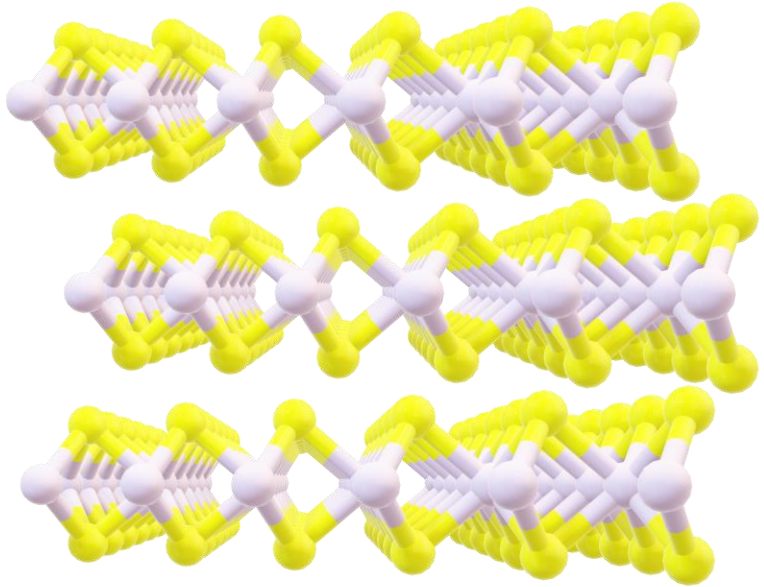
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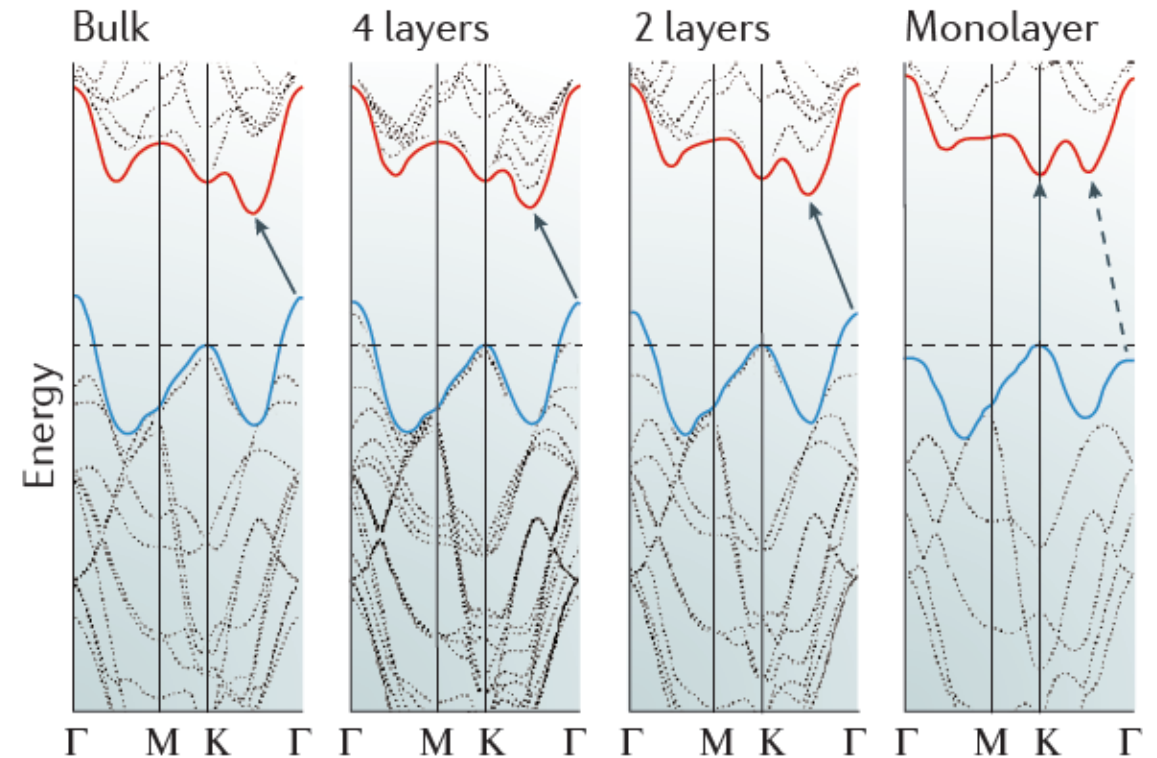
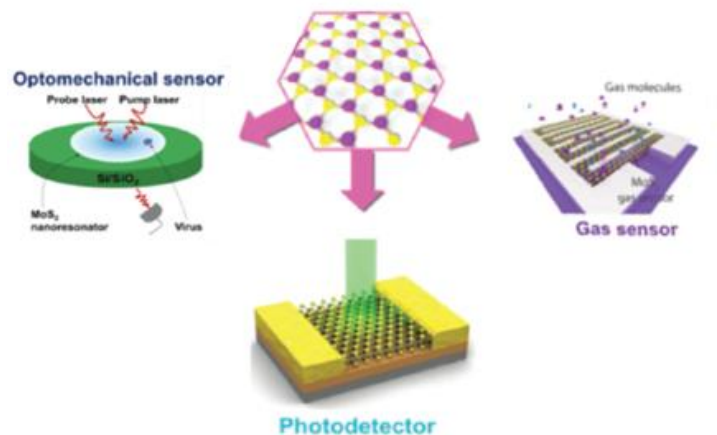
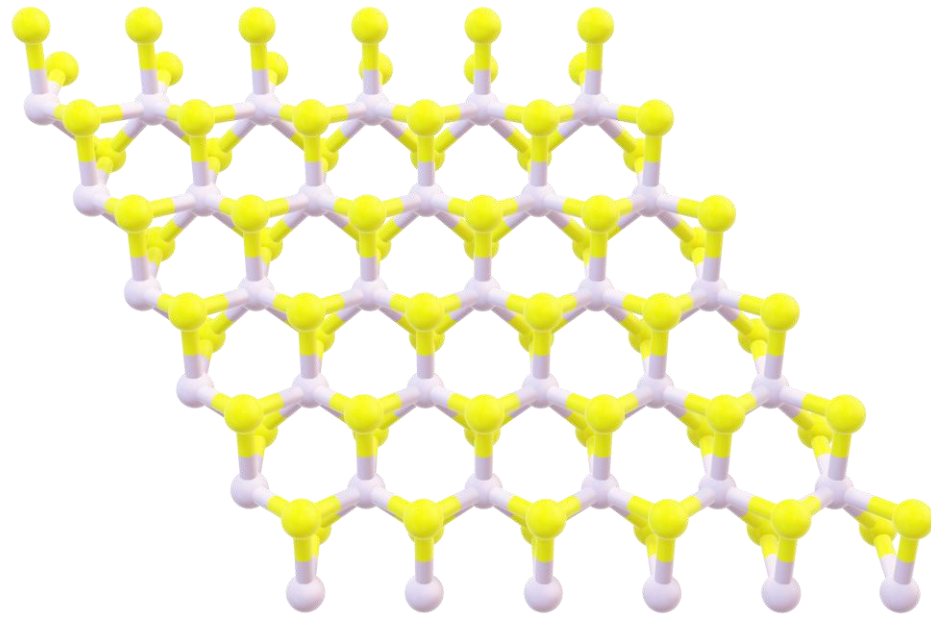
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Molybdenum Disulfide (MoS_2)



Molybdenum Disulfide (MoS₂)



- Transition from **indirect to direct** band gap semiconductor;
- Emission at **1.8 eV** due to direct **exciton recombination**

What affects 1L-MoS₂ properties?

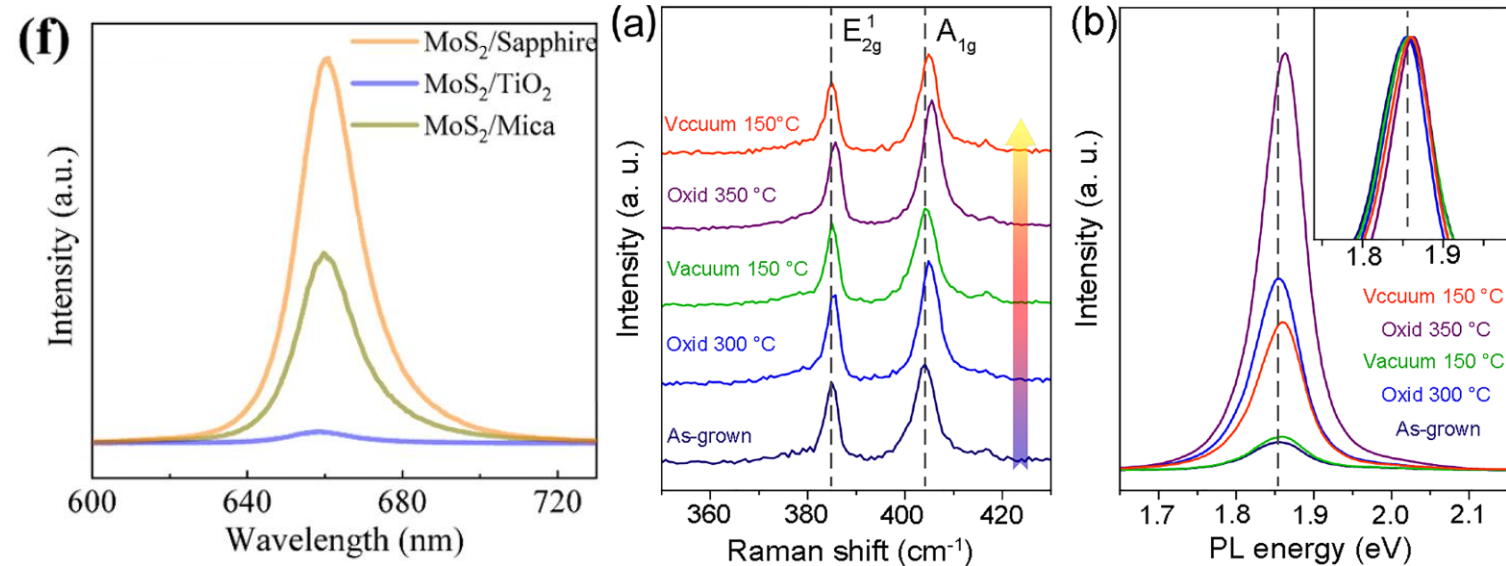
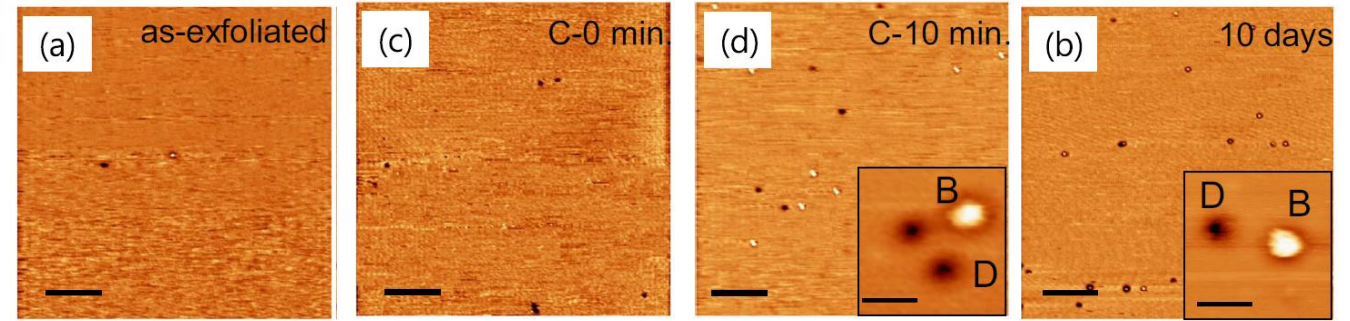
Several methods of production

but...

Each of them confers different characteristics to the material

For example

Size
Impurity content
Defectiveness
Optical properties
Electronic properties

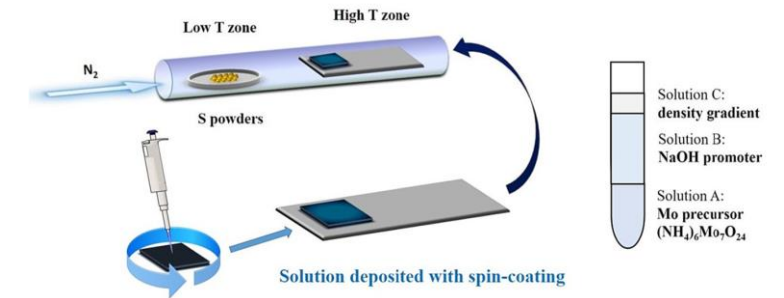
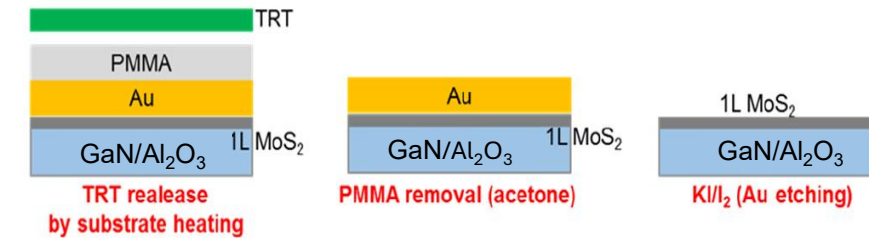
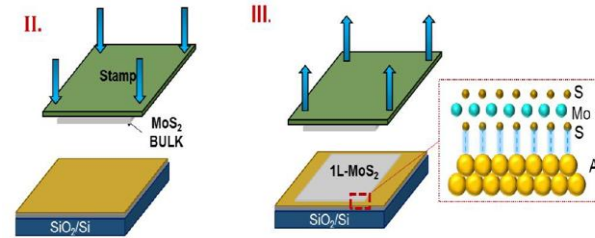


How can we manage the variability?

Case of study

Nanocomposite investigated:

- MoS_2 on Au $\rightarrow$ Gold Assisted Exfoliation
- MoS_2 on GaN and SiO_2/Si $\rightarrow$ Gold Assisted Transfer
- MoS_2 on SiO_2/Si $\rightarrow$ Chemical Vapor Deposition



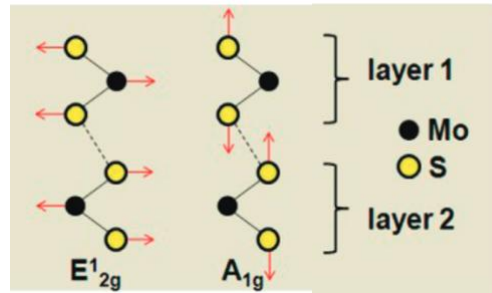
Linkam cell THS 600



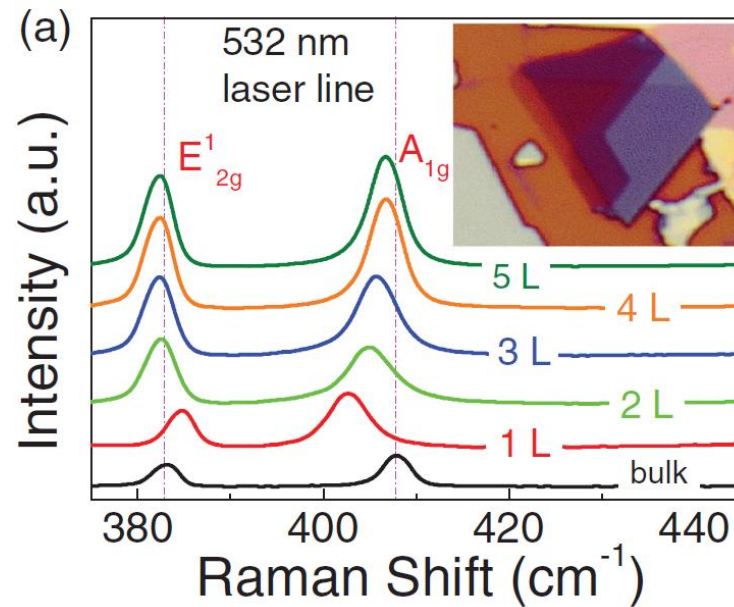
- Thermal treatments were performed to tailor structural and optical properties after synthesis;

Strain-Doping Evaluation of MoS₂

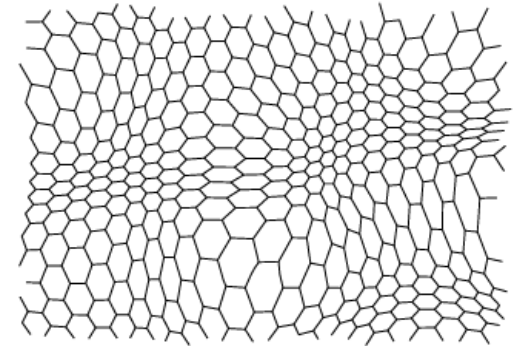
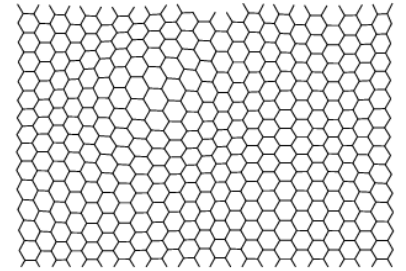
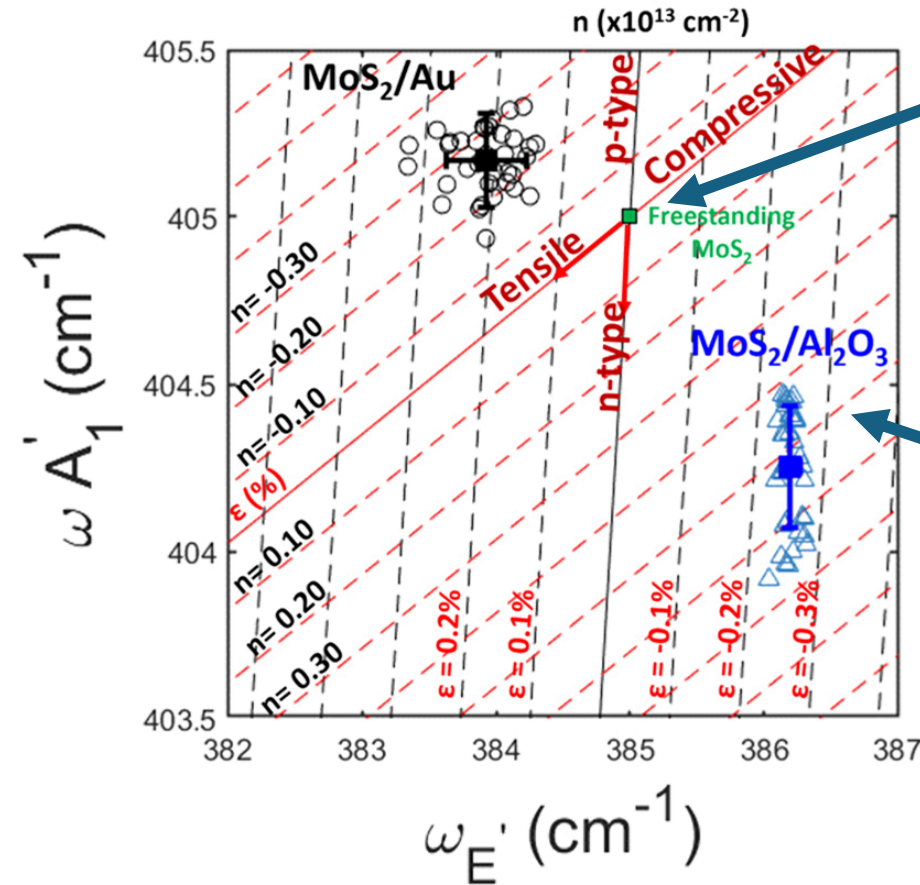
Out-of-plane mode



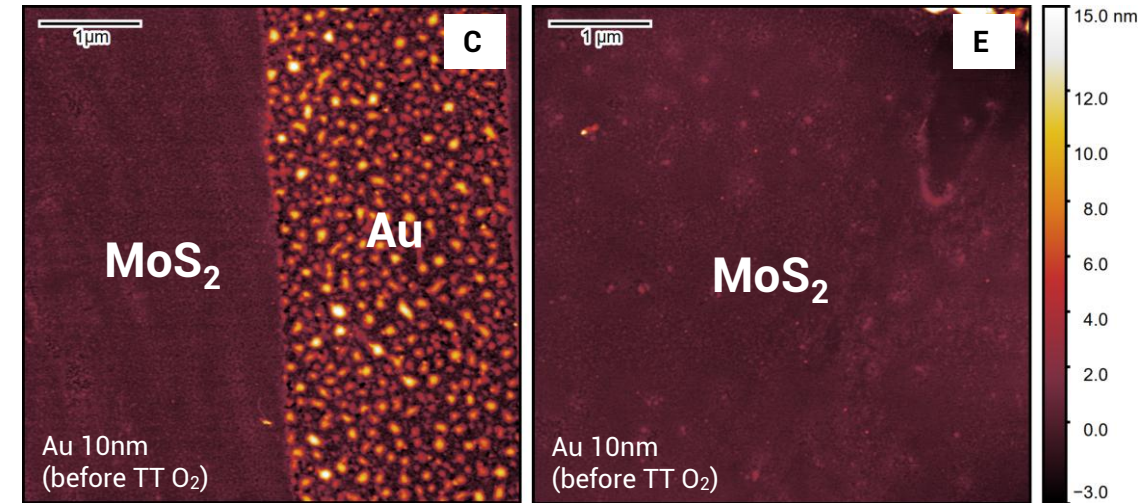
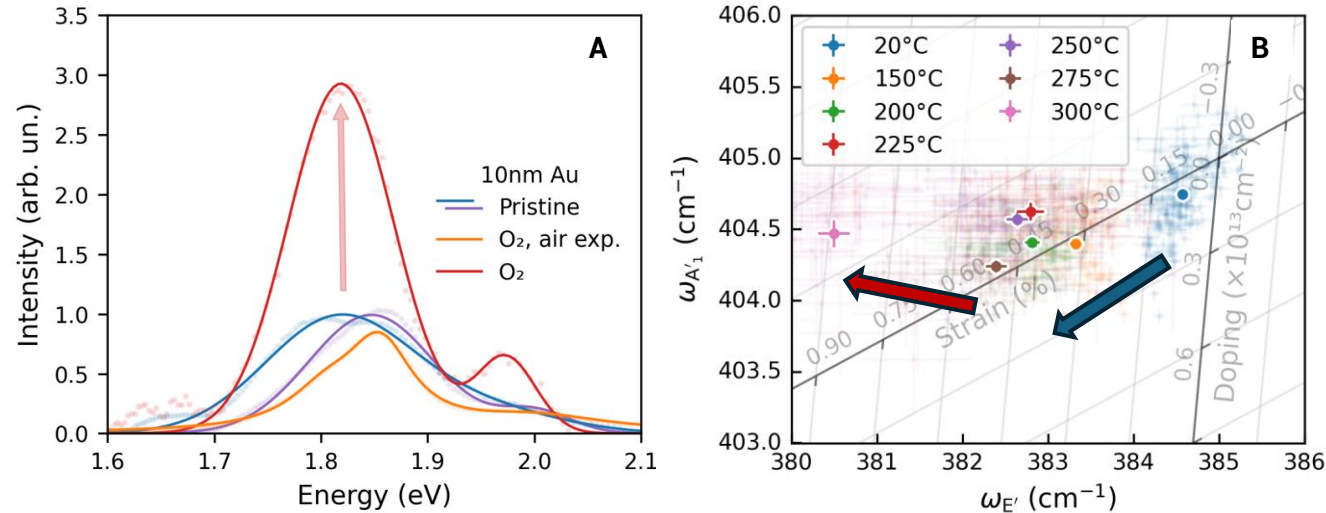
In-plane mode



- Raman peaks are sensitive to strain and doping

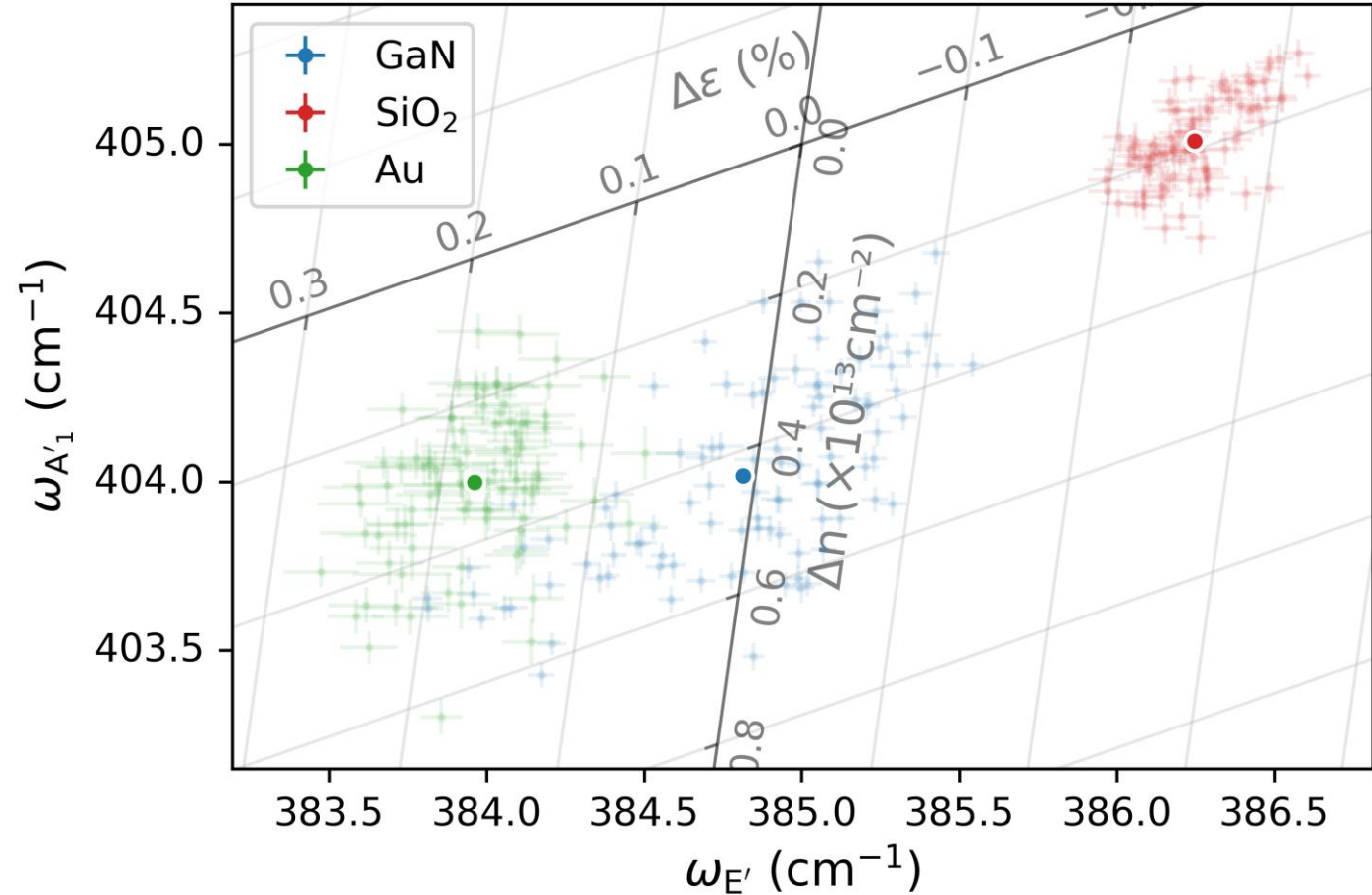
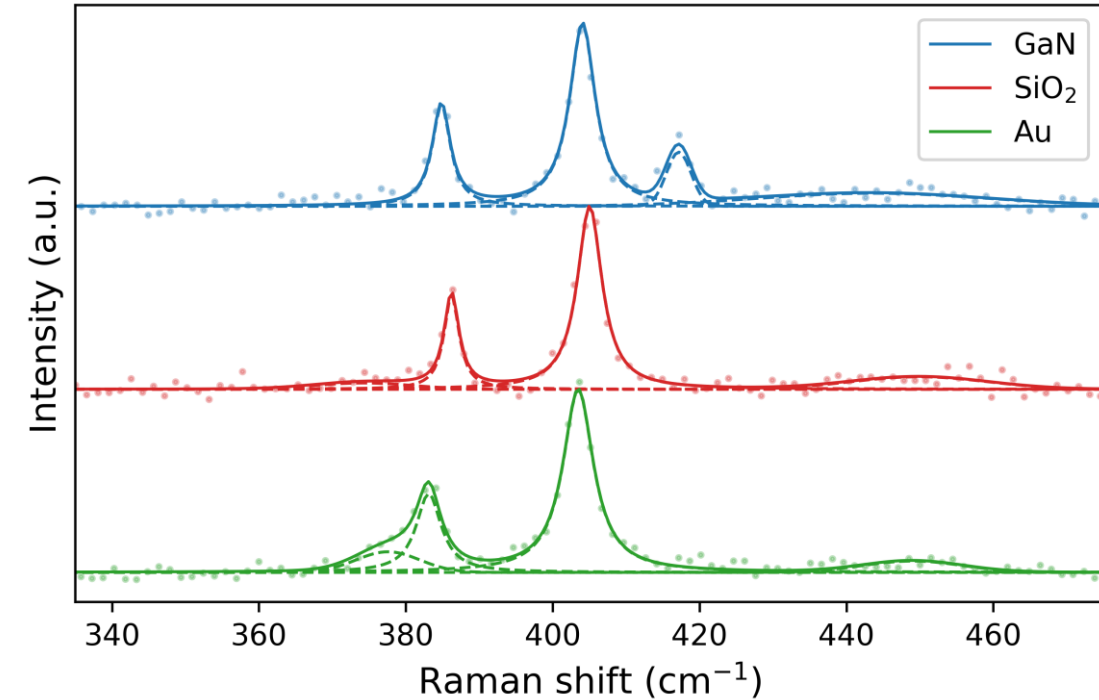


1L-MoS₂ on Au by Gold-Assisted Exfoliation



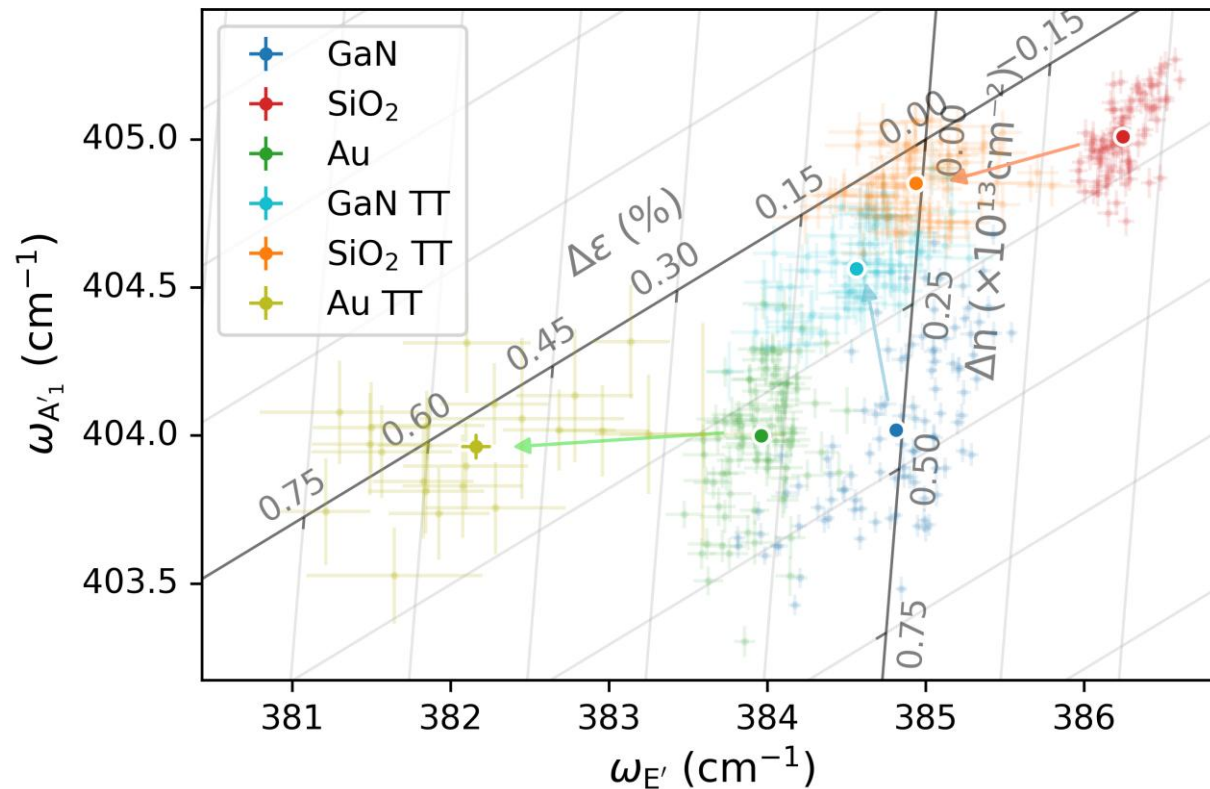
- Single-layer **MoS₂** on **Au** via Gold-Assisted Exfoliation (**GAE**)
- Performed thermal treatments in **O₂** to **tailor strain and doping** after synthesis;
- Best conditions: **2h, 225 °C** in **O₂** atmosphere;
- Inducing **p-type doping** and increasing **tensile strain**;
- **Improving the fluorescence** of a single-layer **MoS₂**.

Strain-doping MoS₂: exfoliated

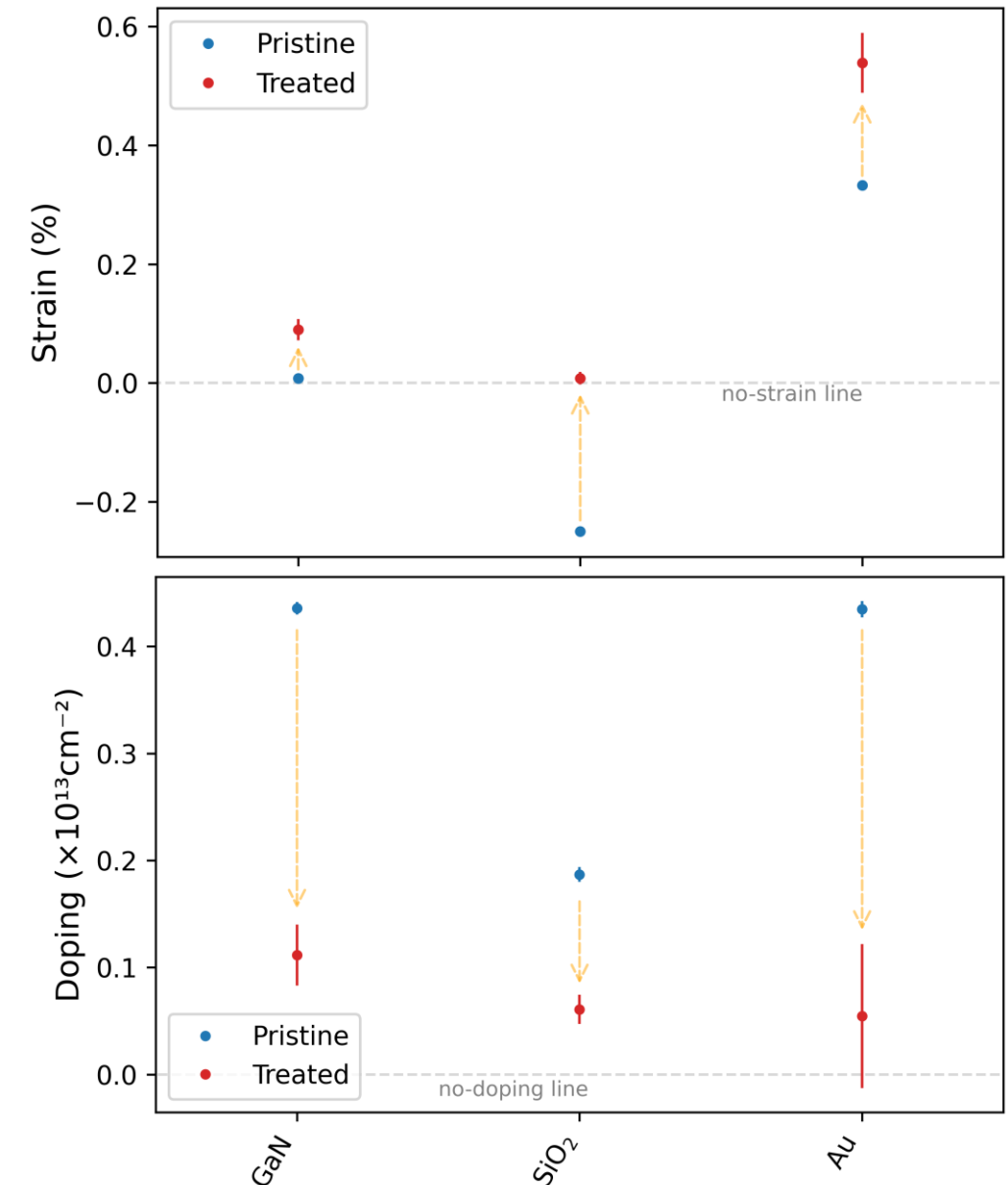


- Different strain values for each substrate;
 - Same type of doping (n-type), independently of the supporting material.

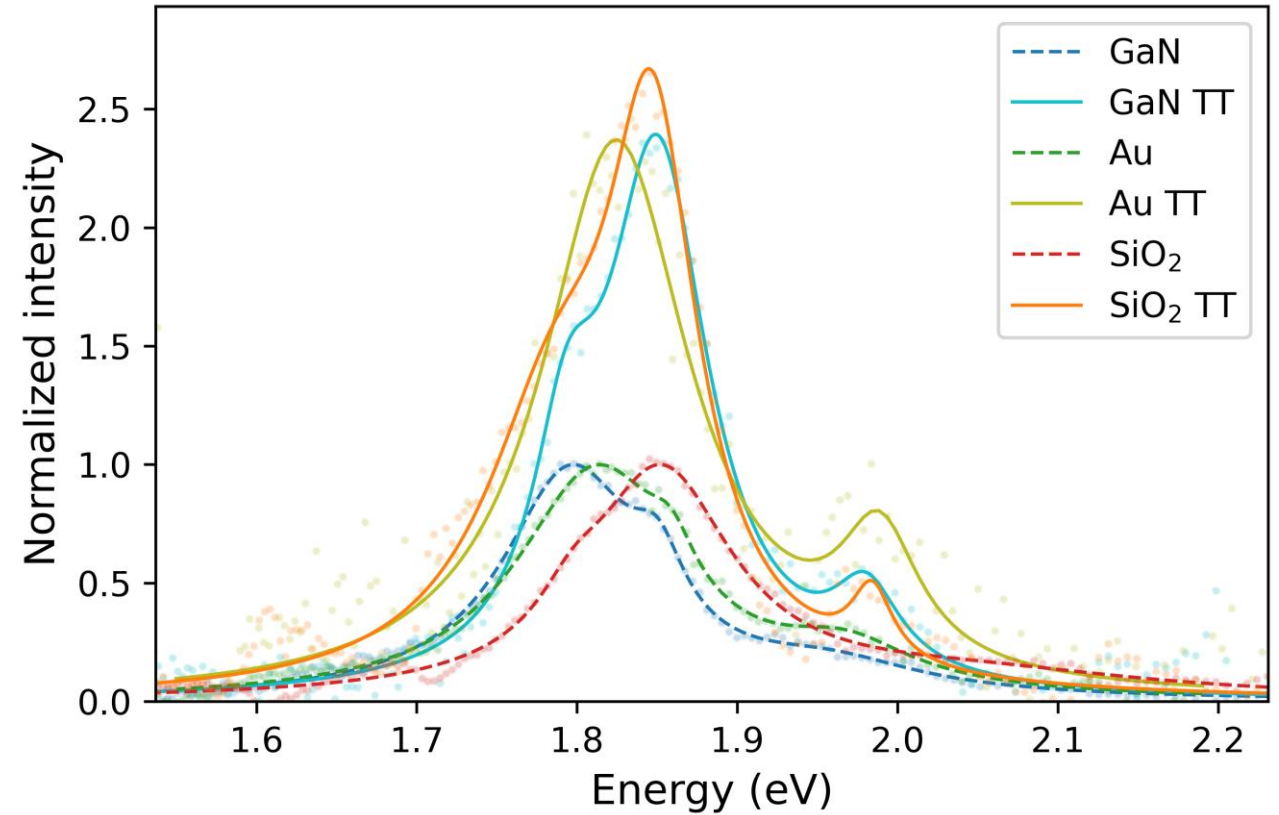
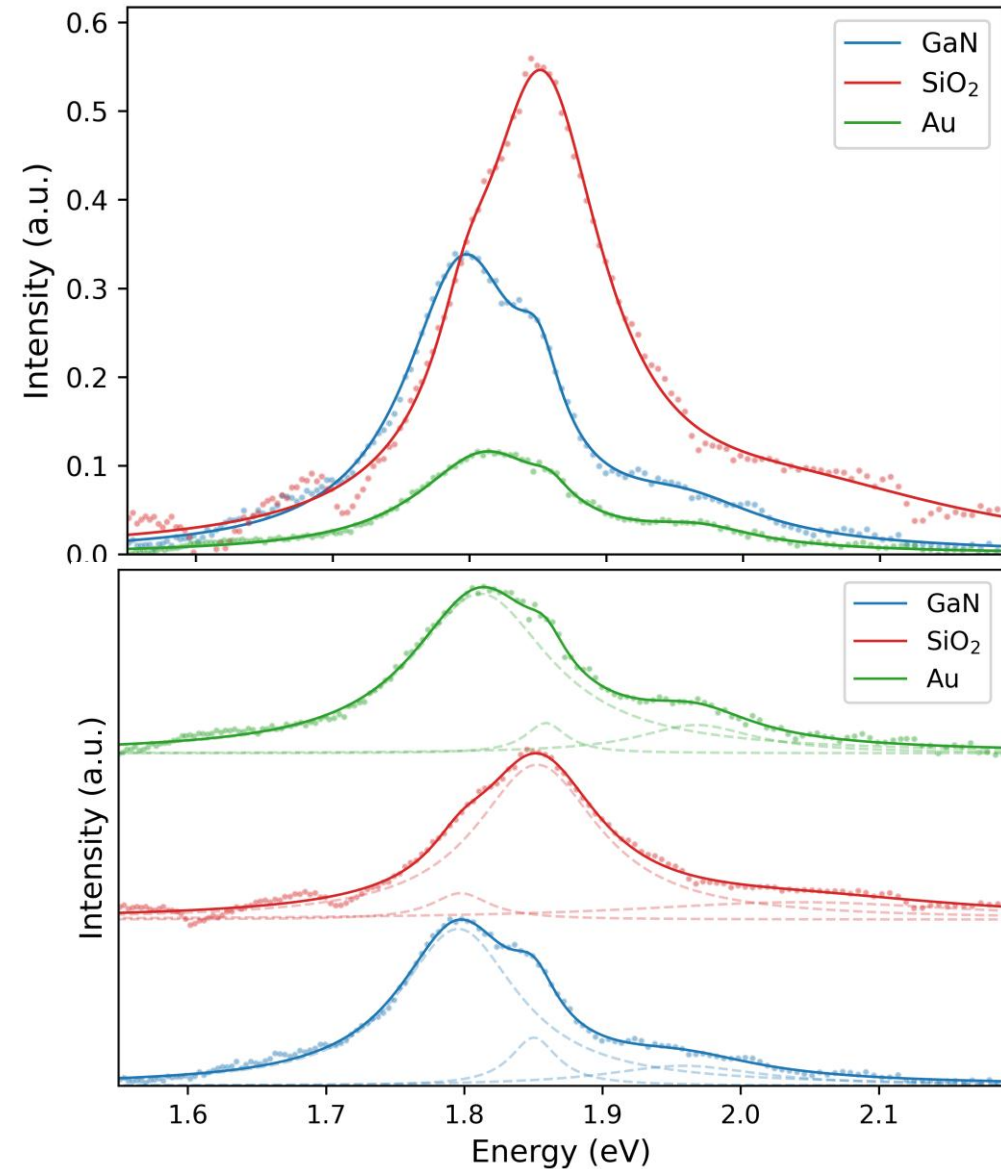
Strain-doping 1L-MoS₂: exfoliated and treated



- **Increased** tensile strain after the treatment;
- **Reduction** of n-doping after treatment;
- **Levelling** the doping conditions.

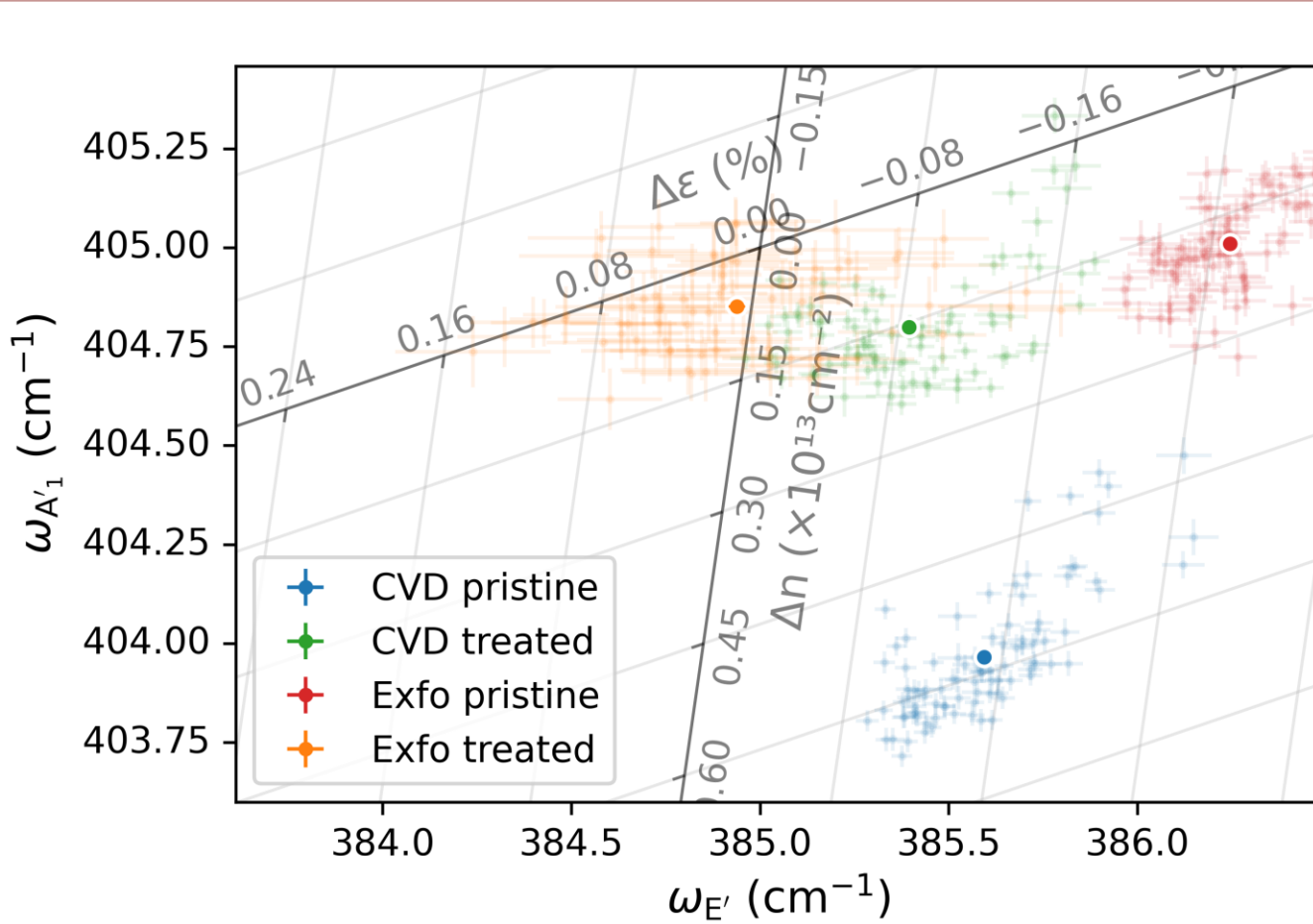


Photoluminescence MoS₂: exfoliated samples

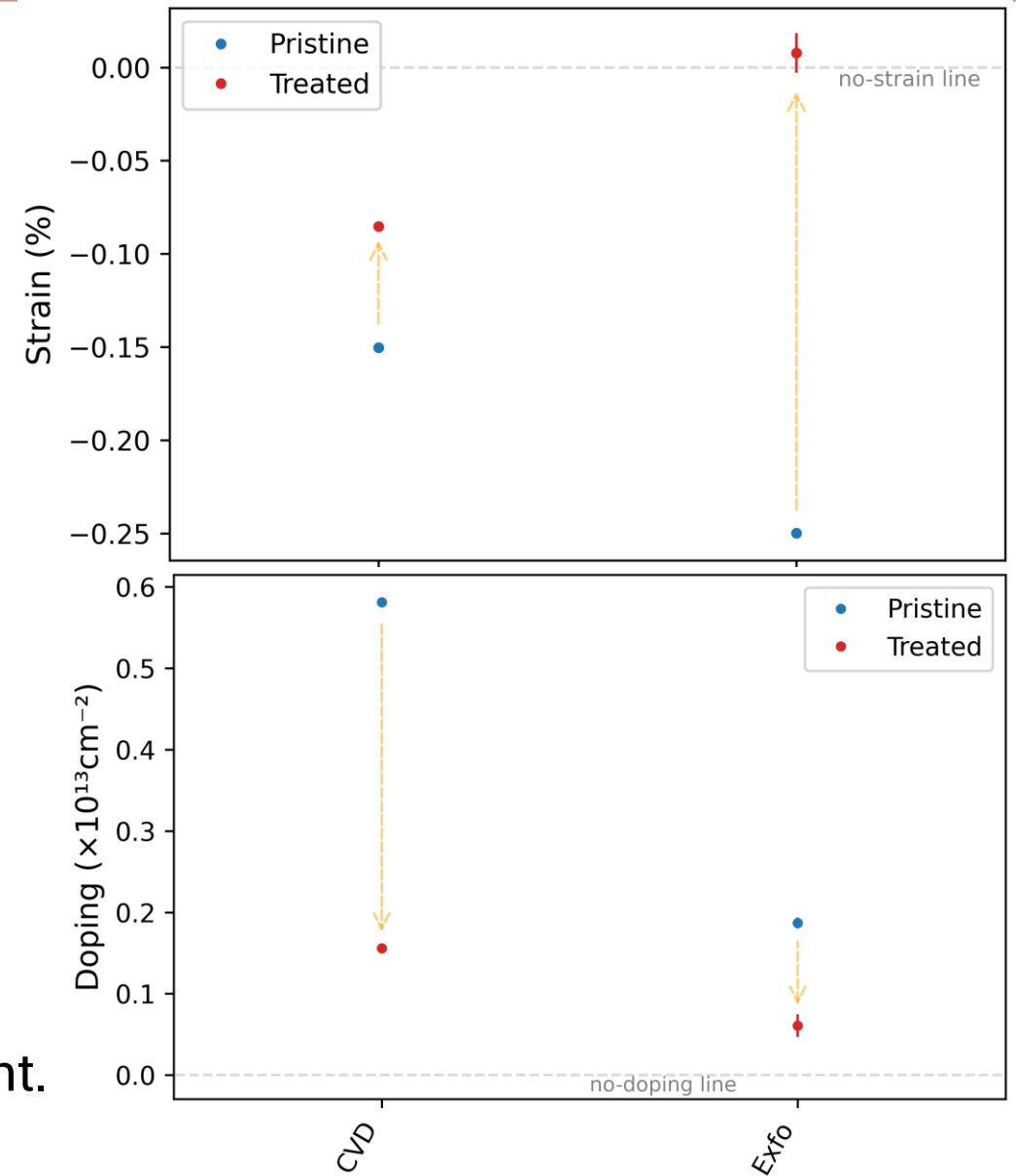


- Each sample has its **characteristic band shape** and **intensity**;
 - the band shapes **after treatment**;
 - **PL intensity** shows the **same relative increase** (~3-fold) **post-treatment**.

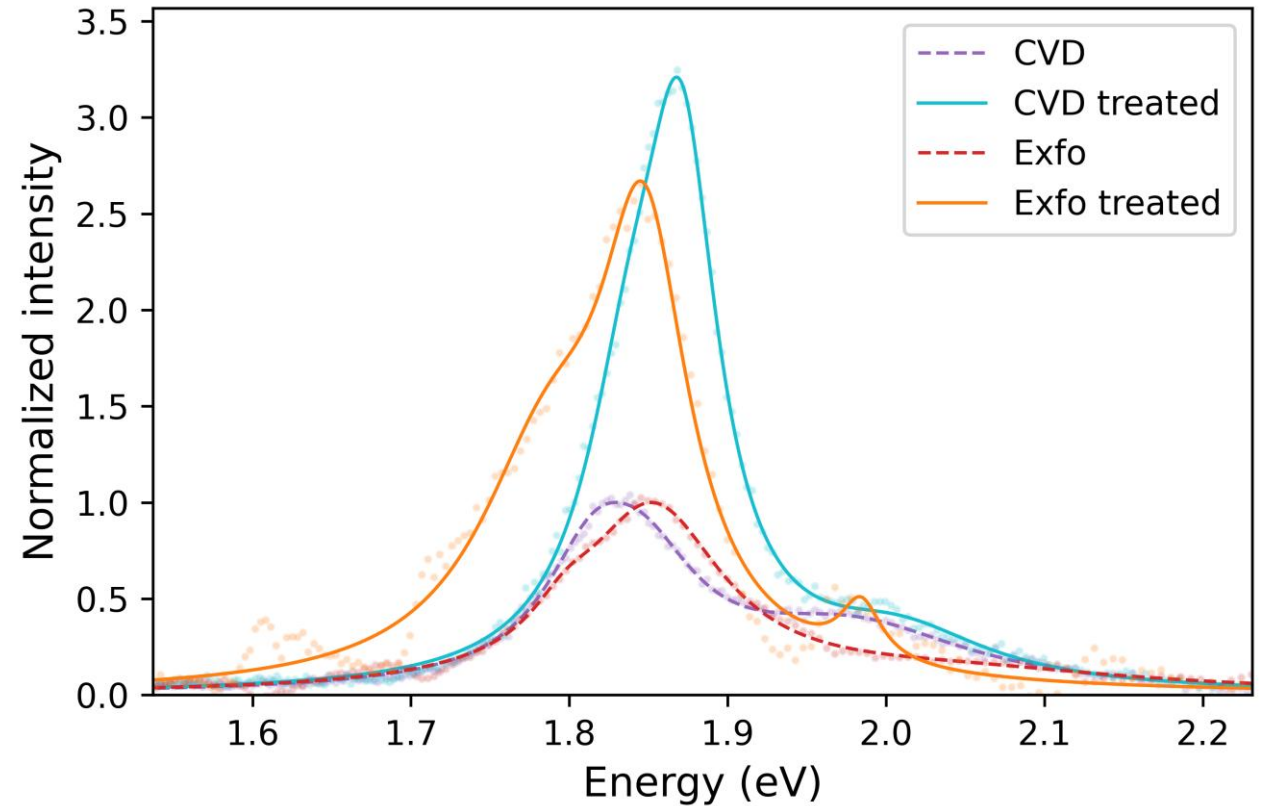
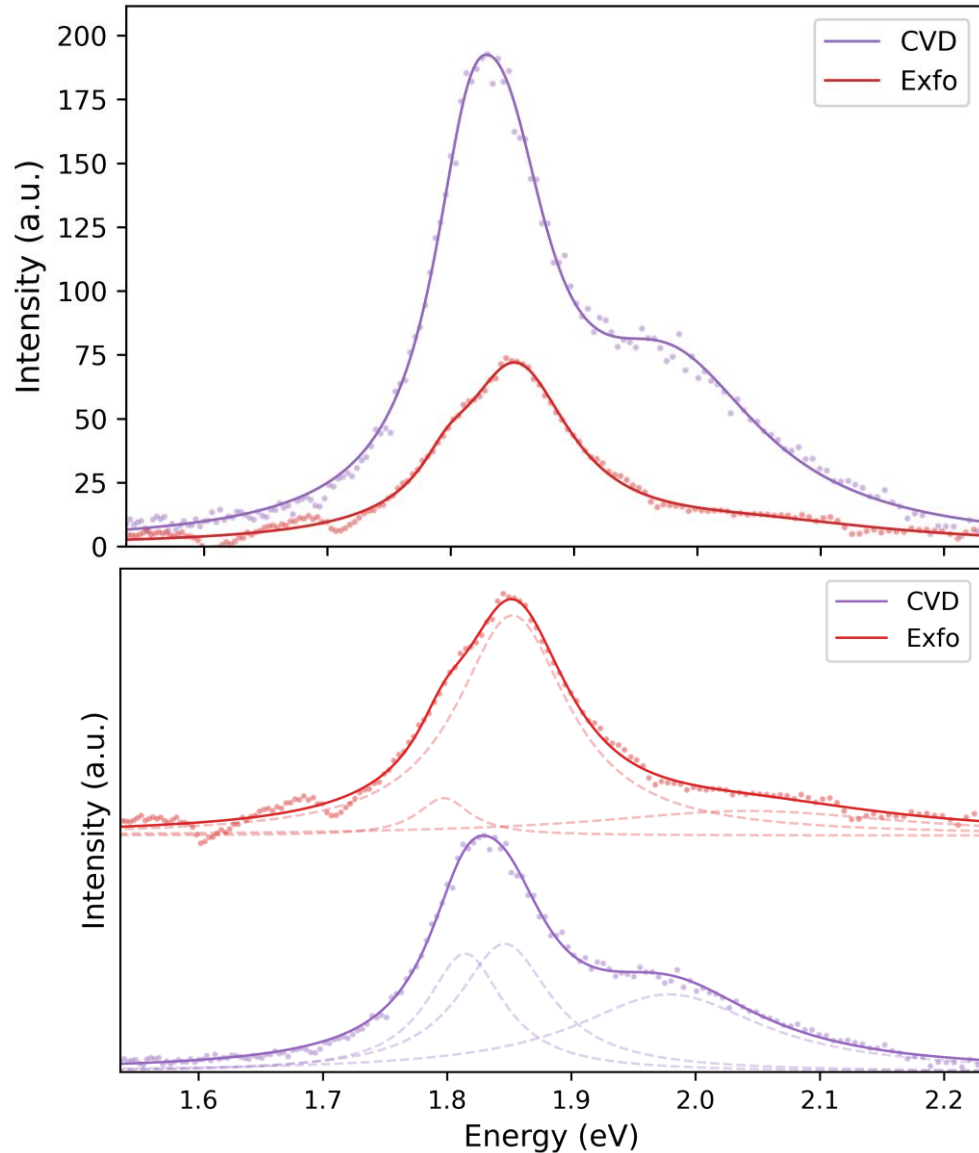
Strain-doping MoS₂/SiO₂: exfoliated vs CVD



- Different strain values for each substrate;
 - Comparable type of doping (n-type) post-treatment.



Strain-doping MoS₂/SiO₂: exfoliated vs CVD



- Each sample has its **characteristic band shape and intensity**;
 - **Changes in the band shapes after treatment**;
 - **PL intensity shows the same relative increase (~3-fold) post-treatment.**

Take-home messages

- ✓ We performed **thermal treatment** in O_2 on **1L-MoS₂** on conductive, semiconductive and insulating substrate;
- ✓ O_2 treatment at **225 °C** seems to **affect doping** of 1L-MoS₂ **without damage** it:
 - filling sulfur vacancies;
 - Removing interstitial carbon contamination from the material;
- ✓ Significant **increase** of **photoluminescence** after O_2 **exposure**, likely due to filling of the sulfur vacancies, **reducing trapping states**;
- ✓ Treatment has an **effect despite** the route of **synthesis** and the **substrate type**;

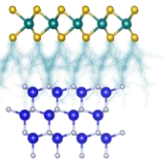
- **Evaluating the conduction properties** after treatment with in situ **electrical characterization**;
- **Encapsulating** the nanocomposite after treatment **to preserve the advantages** over time;

Acknowledgements



MUR-PNRR project
SAMOTHRACE
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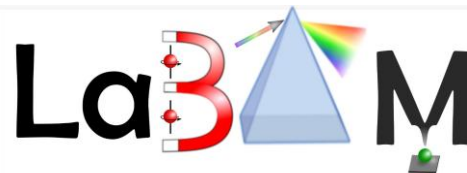
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