GRAPHENE AND 2DM VIRTUAL CONFERENCE & EXPO

10 ANNIVERSARY

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Thickness Dependent Thermal Conductivity of Suspended $MoSe_2$ 2D Crystals via Raman Thermometry

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Ultrafast Dynamics in Nanoscale Systems

Highlights

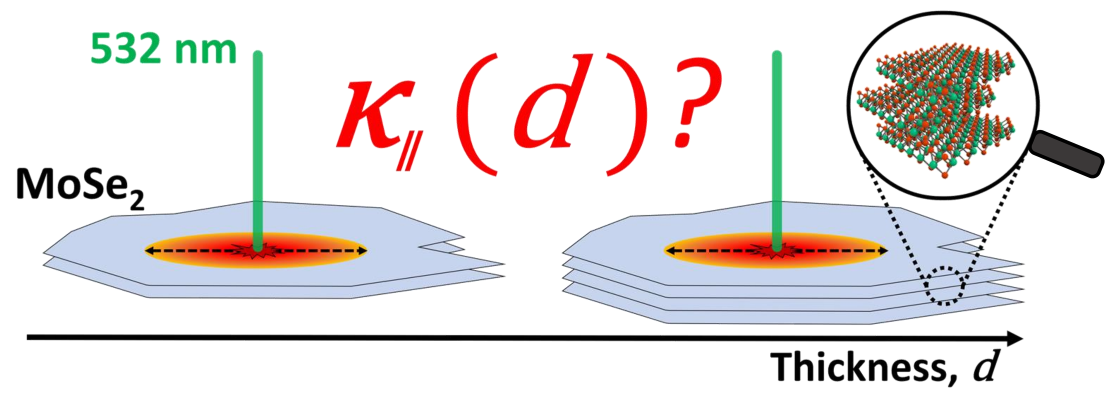
Exfoliated $MoSe_2$ flakes, suspended over large-area (175 µm²) holes

Measurements performed on >10 samples with 1 – 10L, including a monolayer and three bilayers

Non-monotonic thermal conductivity as a function of number of layers

Introduction

How does $MoSe_2$ thermal conductivity depend on thickness?



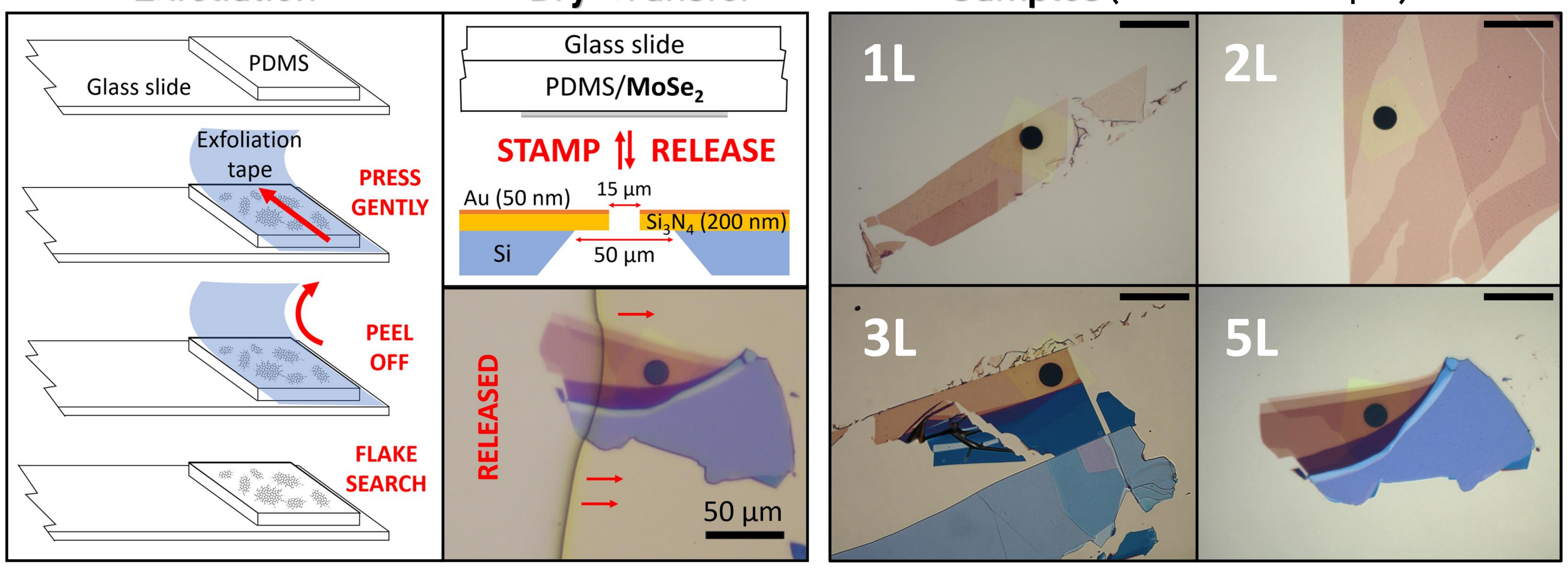
This question is still debated in the literature: [1], [2], [3], [4]

We use Raman Thermometry to measure the in-plane thermal conductivity (κ) as a function of thickness (d)

Fabrication

Au-coating the substrates enhances $MoSe_2$ adhesion, improving the transfer yield on 15 µm holes

Exfoliation | **Dry-Transfer** | **Samples** (scale bars = 50 µm)

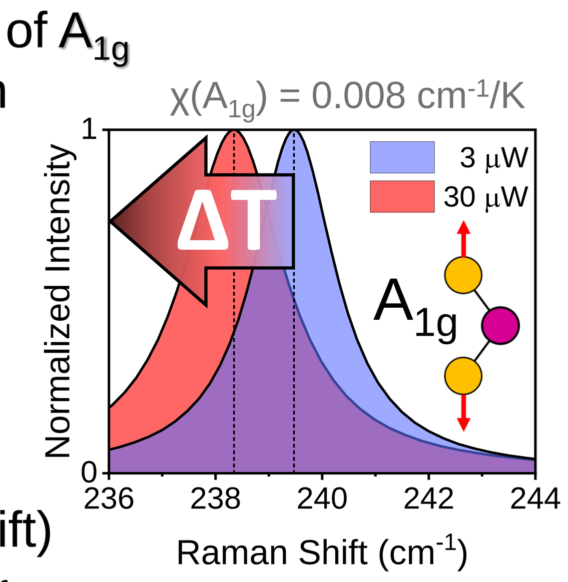


Raman Thermometry

The Raman peak of A_{1g} mode depends on temperature (T)

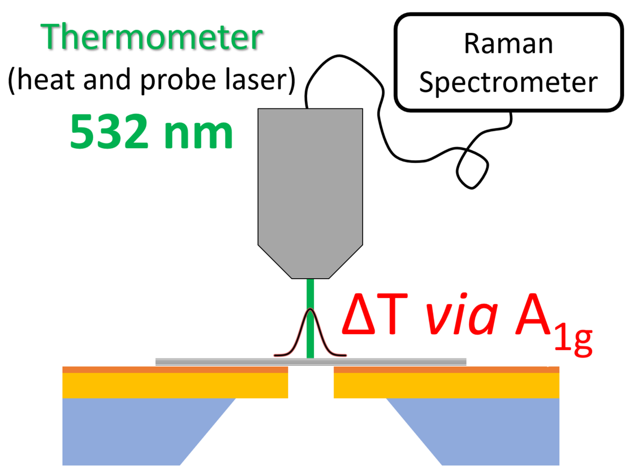
A CW laser heats the centre of the suspended flake

We monitor ΔT (from the peak shift) vs. incident power



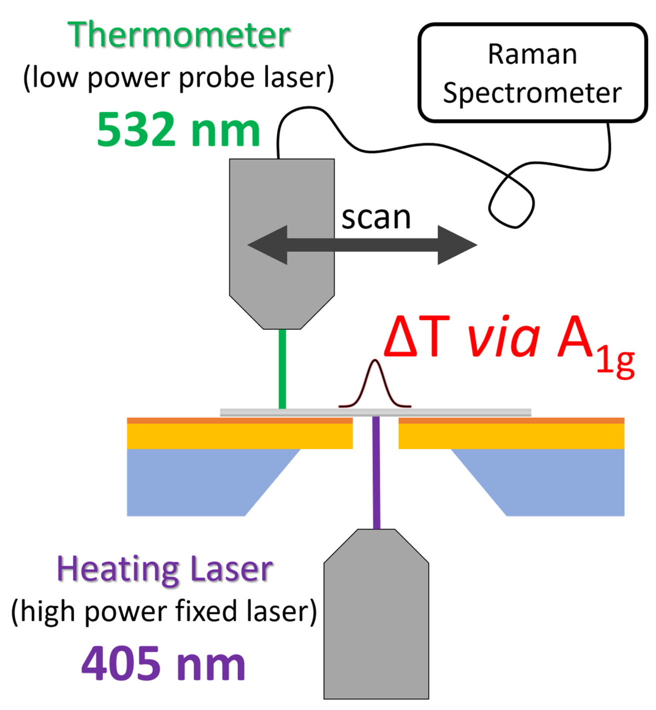
1LRT

1-Laser Raman Thermometry:



2LRT

2-Laser Raman Thermometry:



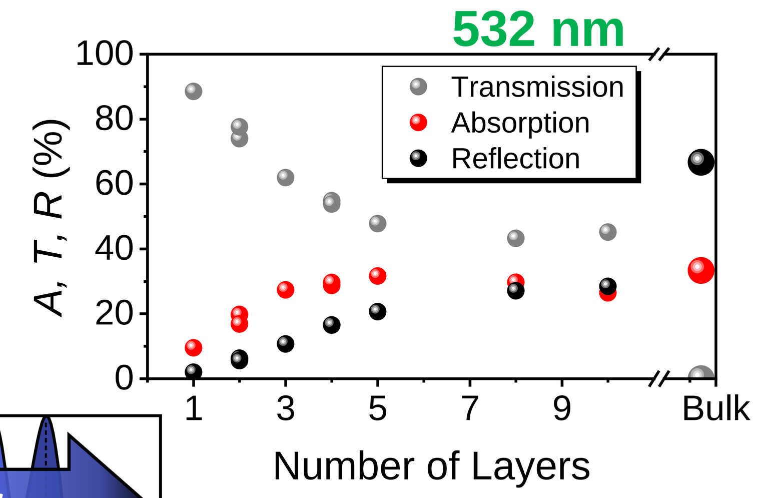
We retrieve thermal conductivity:

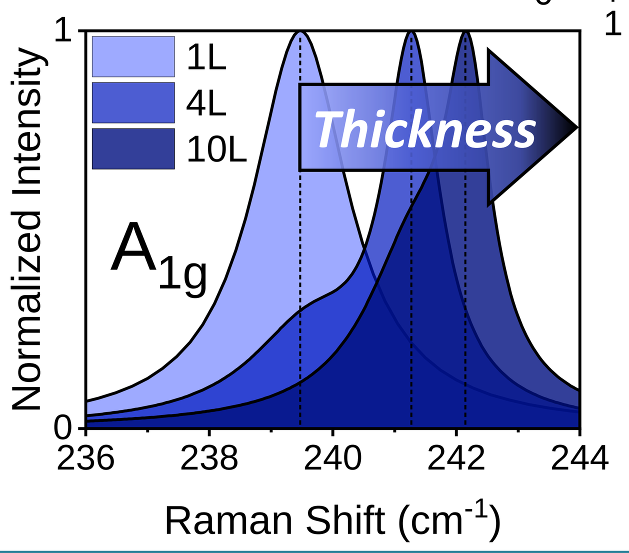
$$\kappa = \frac{1}{2\pi d} \cdot \frac{1}{dT/dP_{abs}} \cdot \ln\frac{R}{r_0} \cdot \alpha$$

(R = 15 µm, r_0 = 0.9 µm, α ≈ 1)

Characterization

The suspended monolayer absorbs ~9.5% of light



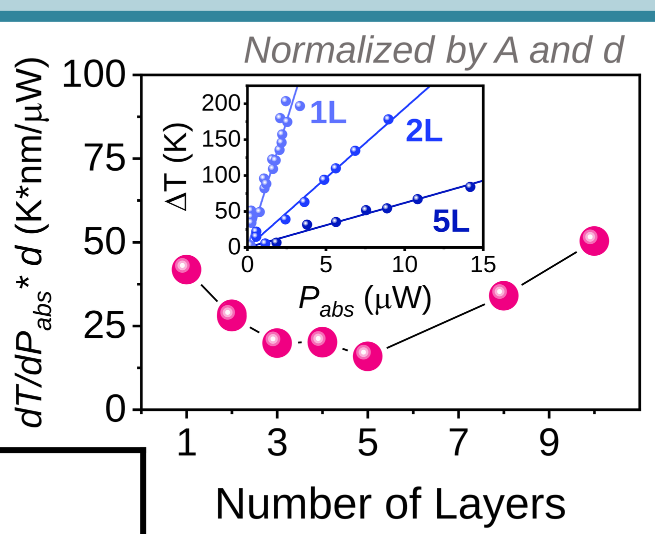


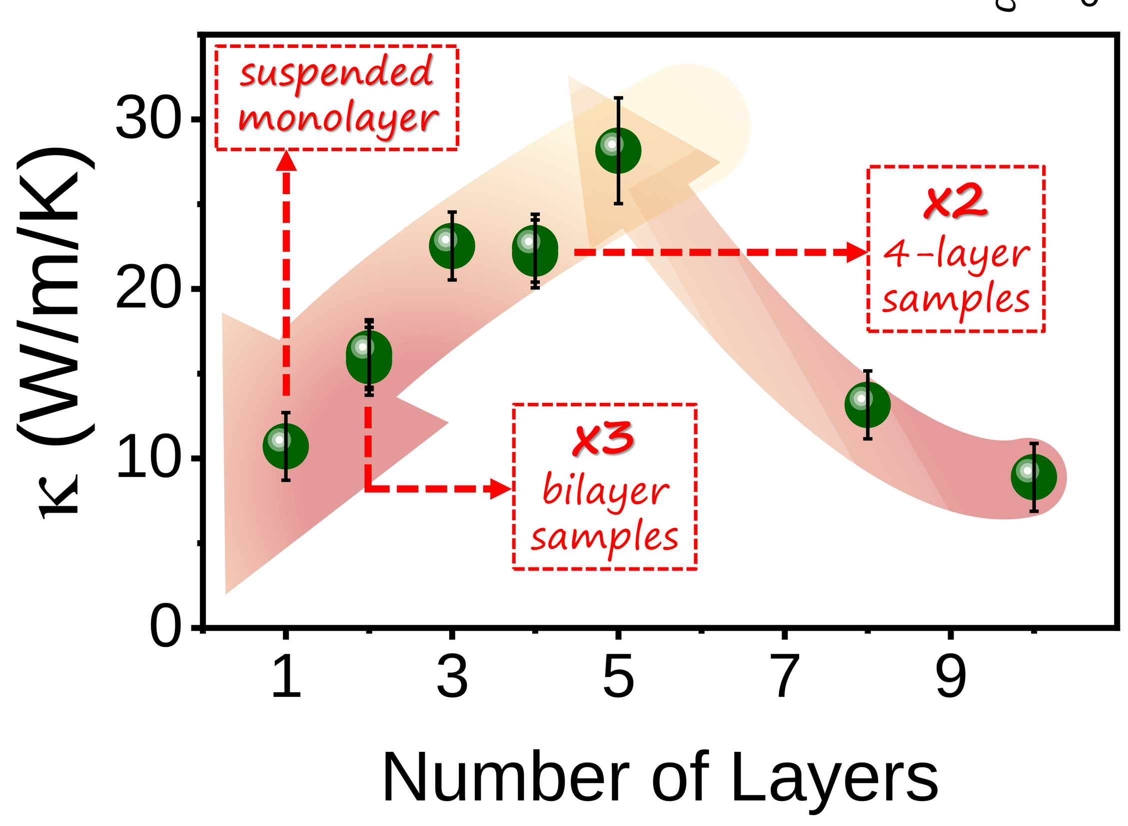
Thickness confirmed with Raman Shift at low power

...& AFM

Results & Discussion

1LRT suggests a 3-fold decrease in κ from 5L to 1L!



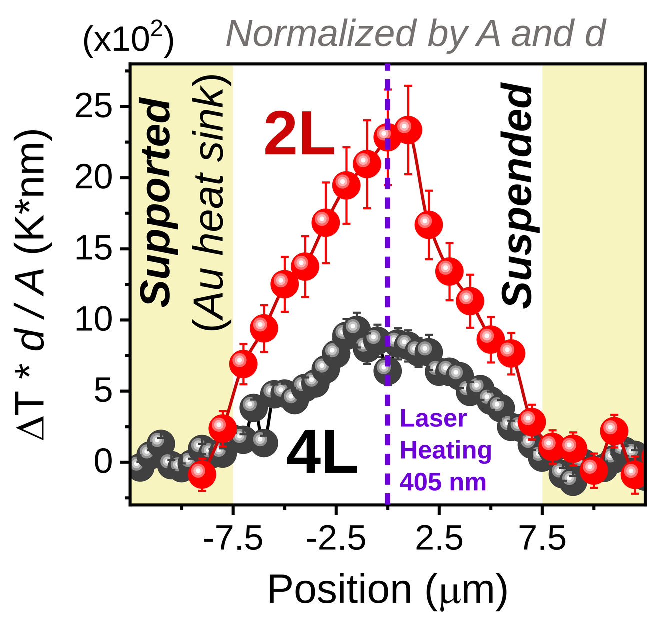


Highly reproducible κ for samples with equal number of layers

Triangular profiles indicate steady-state

2LRT confirms a different κ for samples with 2L and 4L

Perfect heat sink at the edge of the hole

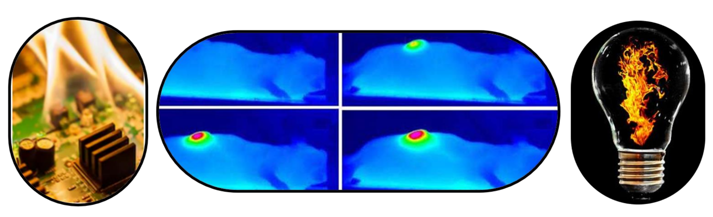


Conclusions & Outlook

Thermal conductivity shows a non-monotonic trend with thickness (or number of layers)

Thickness could serve as an important design parameter in emerging applications:

- Heat Management
- Photothermal Therapy
- Thermoelectricity



Next Steps...

DFT theory to fully understand the experimental observations

More measurements on a different monolayer sample and on thicker ones

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References

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