Quantitative scanning thermal microscopy studies of the influence of interfaces and heat transport anisotropy in 2D materials

S. Gonzalez-Munoz[1], K. Agarwal[1], A. Maiti[2,3], and O. V. Kolosov[1]

[1]Lancaster University, [2]Indian Association for the Cultivation of Science, [3]Université Paris-Saclay

Introduction

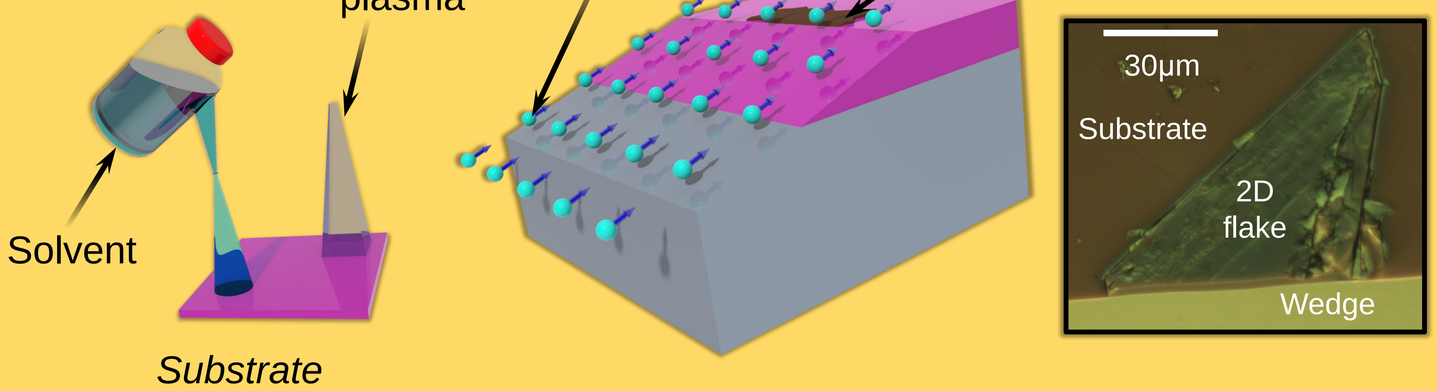
? Intrinsic *anisotropy* in bi-dimensional materials.[1]

? *Interface* / substrate role in the heat transport.[2]

? True *nanoscale resolution* of thermal properties depending on thickness.[3]

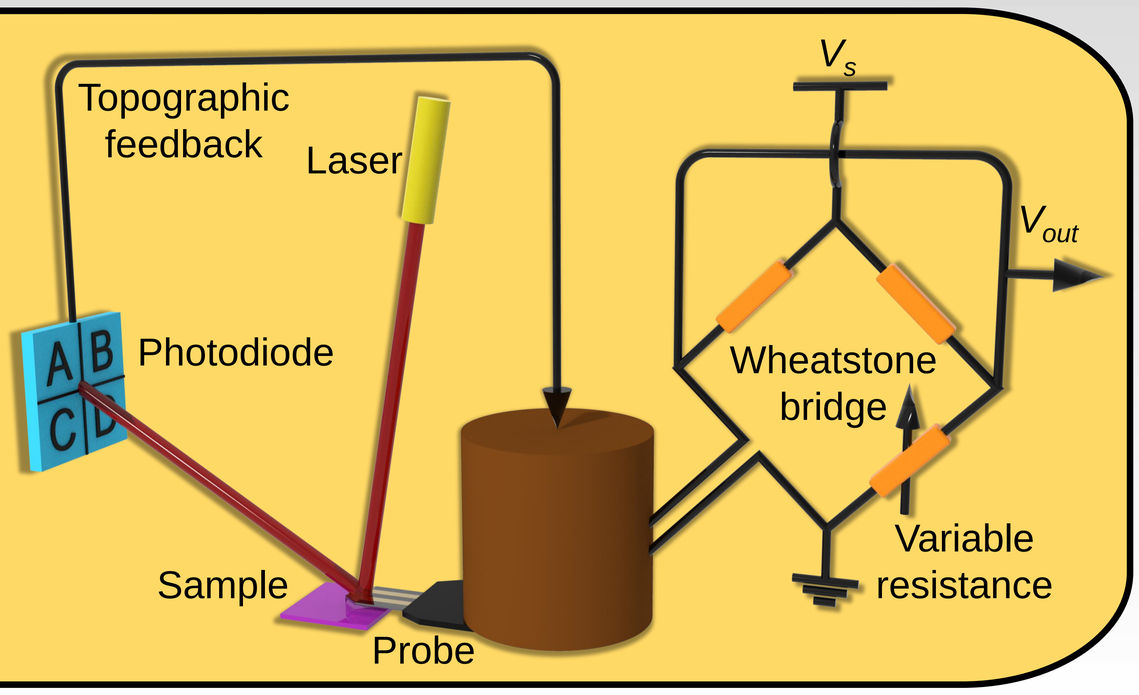
- ❑ Thermal transport in anisotropic graphene, γ-InSe, and perovskite.
- ❑ Interface effects on Si and SiO_2 substrates.
- ❑ Quantification of anisotropic thermal conductivities and interfacial thermal resistivity.

Fabrication

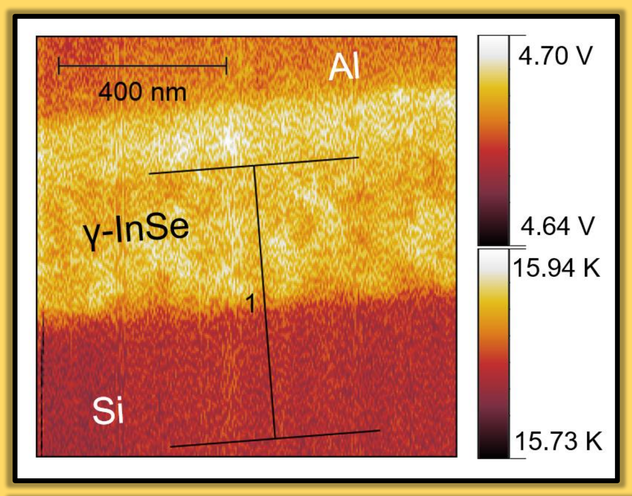


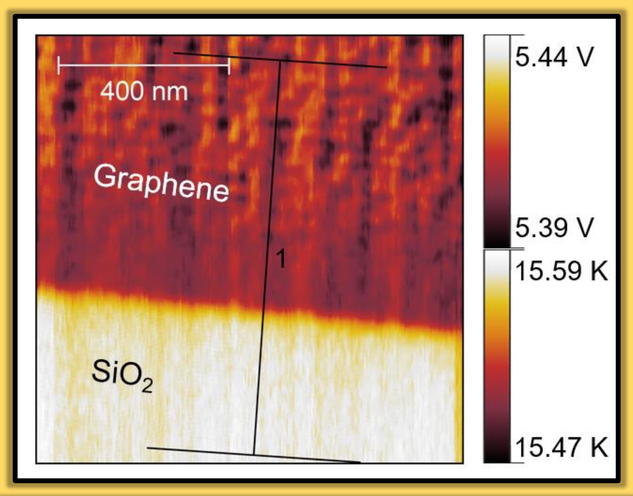
Characterization

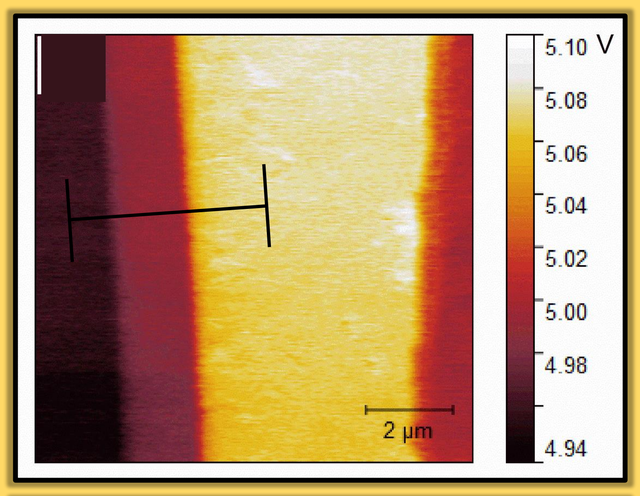
- ❑ HV-SThM (see right scheme) performed under high vacuum conditions and room temperature.
- ❑ SThM's probe incorporates a resistive heater receiving constant power via a DC-AC Wheatstone bridge.
- ❑ $V_{out} \propto T_{probe} \rightarrow T_{probe}$ changes due to variations of the probe-sample heat flow.
- ❑ By moving the probe across the sample surface, a quantitative map of the sample heat transport is obtained.[4]

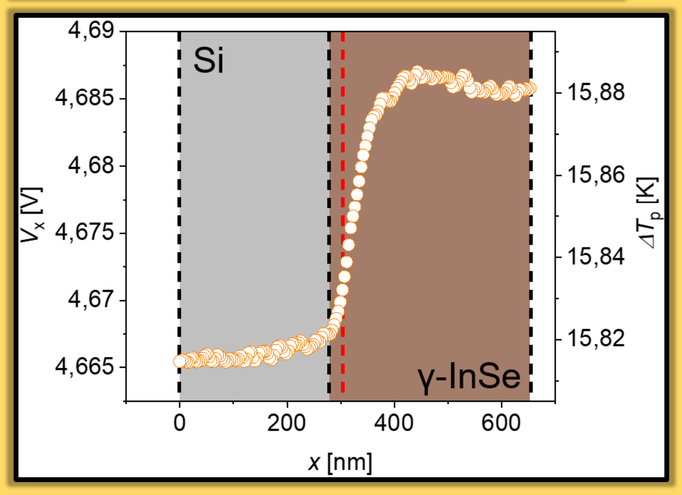


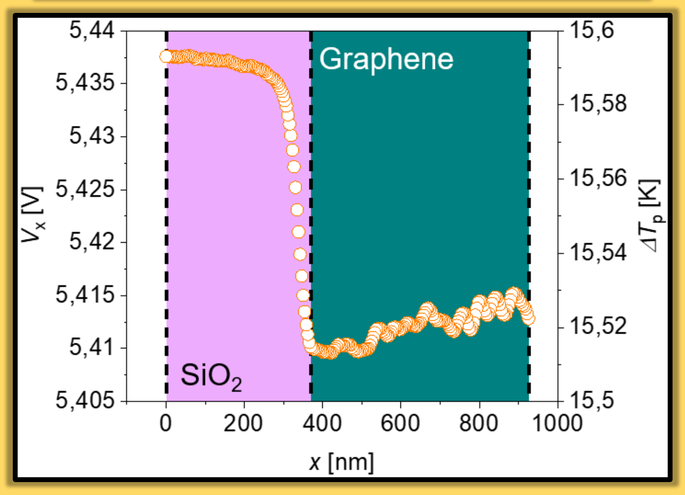
Results

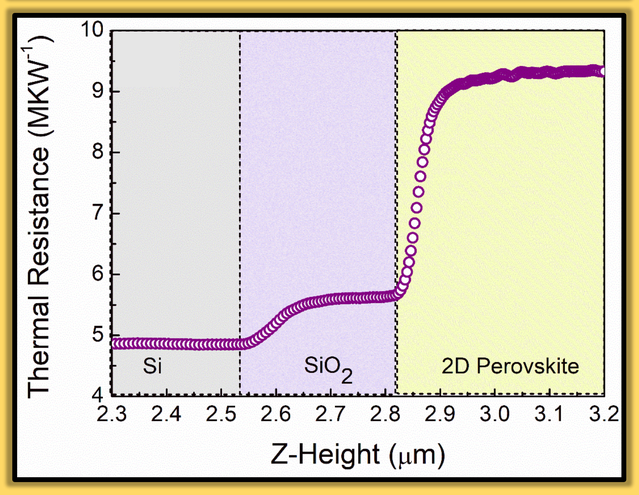












Materials	a [nm]	r_{int} [Km^2W^{-1}]	k_{xy} [$Wm^{-1}K^{-1}$]	k_z [$Wm^{-1}K^{-1}$]
γ-InSe/Si	22.92	9.60×10^{-11}	2.16	0.89
Perovskite /SiO_2	55	100×10^{-11}	0.45	0.13

- ✓ r_{int} affects heat transport up to a limit, then it becomes negligible.
- ✓ Record-low anisotropic k for novel TE devices.
- ✓ True nanoscale resolution of heat transport features.

We acknowledge the financial support of the Graphene Flagship Core 3 project, the EPSRC EP/V00767X/1 HiWiN project and the Paul Instrument Fund. We appreciate the technical support from NT-MDT and Leica Microsystems.

References

1. Gonzalez-Munoz, S. et al. *Adv. Mater. Interfaces* **10** (2023).
2. Buckley, D. et al. *Adv. Funct. Mater.* **31** (2021).
3. Spièce, J. et al. *Nanoscale* **13** (2021).
4. Evangeli, C. et al. *Adv. Electron. Mater.* **5** (2019).