Ming Hsieh Department of Electrical Engineering

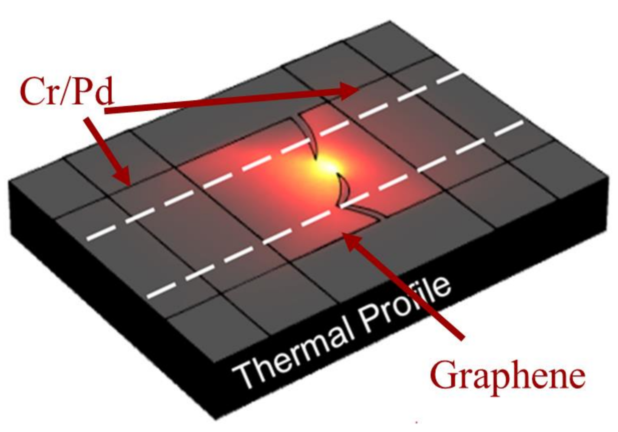
USC Viterbi School of Engineering

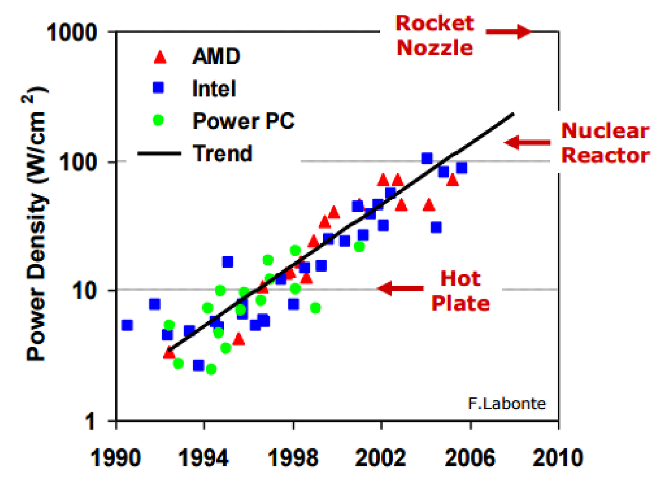
Thermoelectric Transport Across Graphene-*h*BN-Au Heterostructure

Nirakar Poudel[1], Zhen Li[1], David Choi[2], Li Shi[2], Stephen Cronin[1]

Motivation

- Power dissipation major roadblock to scaling trend
- Local thermal hot spots limit performance



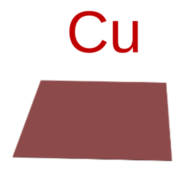


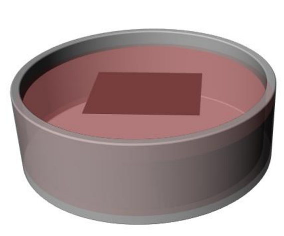
©Pop et al.

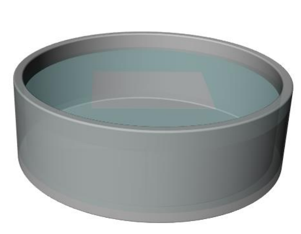
- Fourier Heat Equation and bulk properties not valid. boundaries and Interfaces play major role
- Advancement in fundamental science of nanoscale heat transport imperative for pushing technologies like phase change memories, nanoparticles assisted medical therapies, thermal assisted magnetic recordings

Device Fabrication

Cu



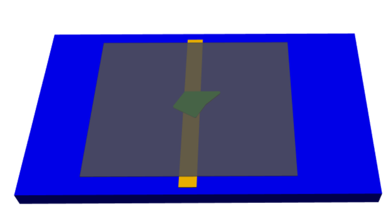




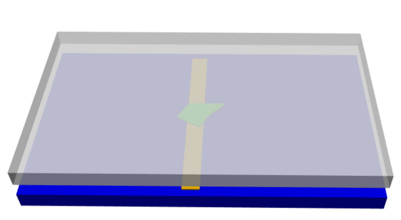
CVD graphene covered by PMMA

Etch away cupper

PMMA Covered graphene film on water

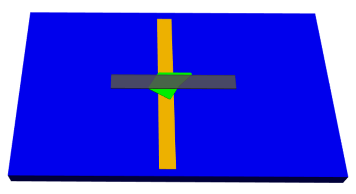


Scoop with base substrate

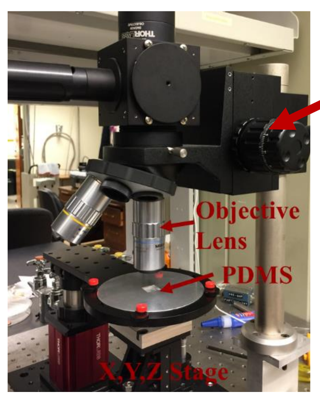


Exfoliate and transfer flakes to PDMS

Align Transfer using the setup

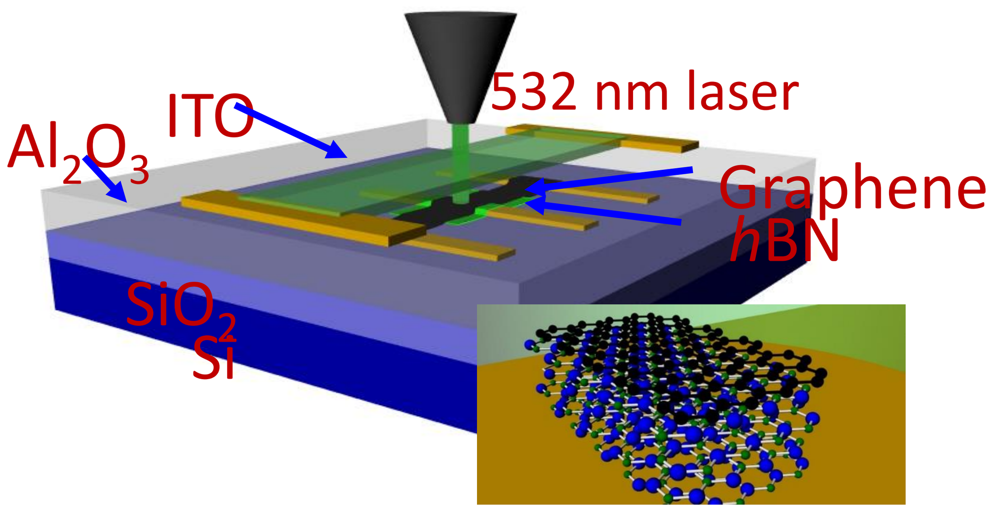


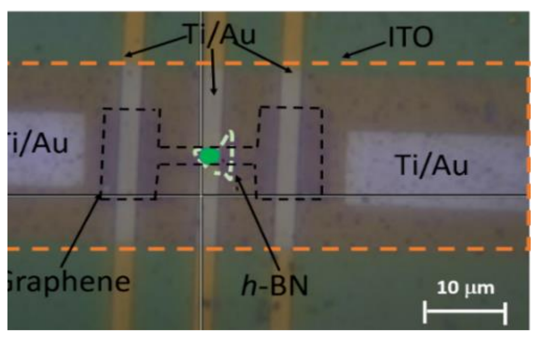
Pattern Graphene using Oxygen Plasma

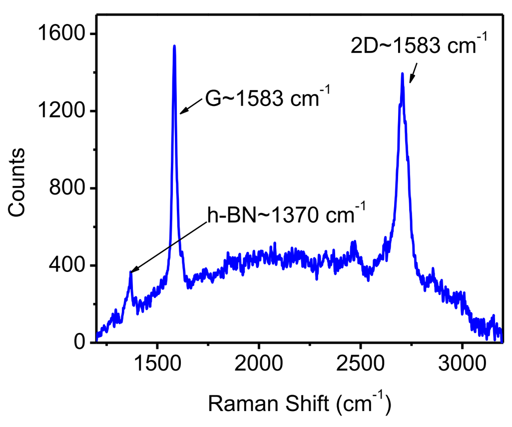


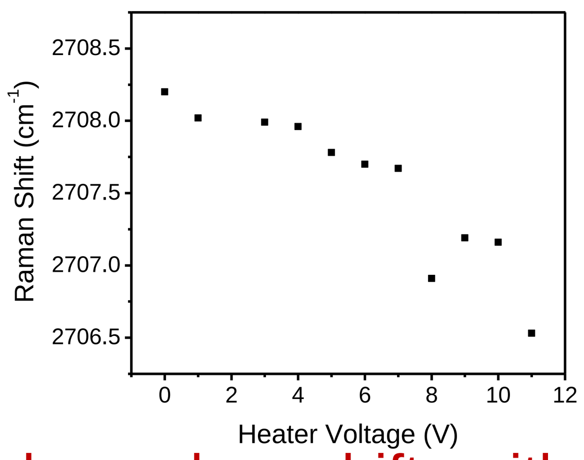
- Atomic Layer Deposition of Al_2O_3 followed by ITO deposition using sputtering

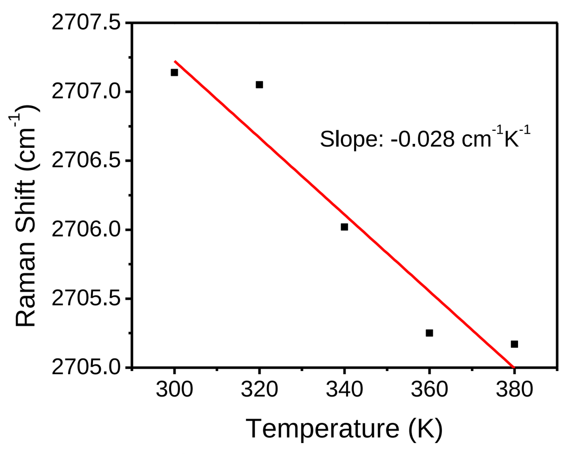
Raman Thermometry









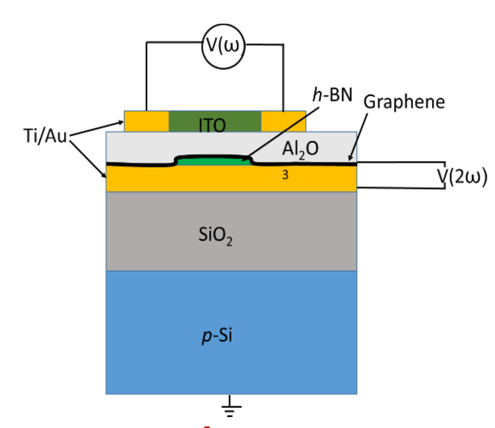


- 2D Peak of Graphene downshifts with increasing temperature

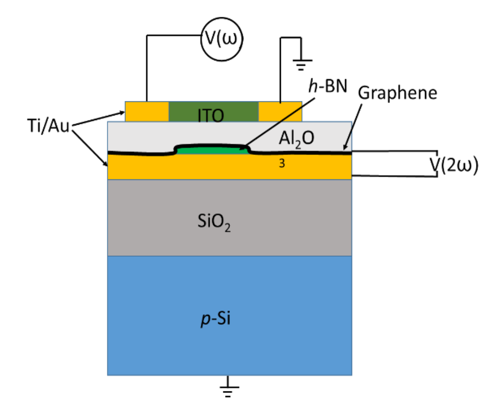
Measurement

$$S = -\frac{\Delta V}{\Delta T} \qquad P = \frac{V^2}{2R}(1 - cos(2\omega t))$$

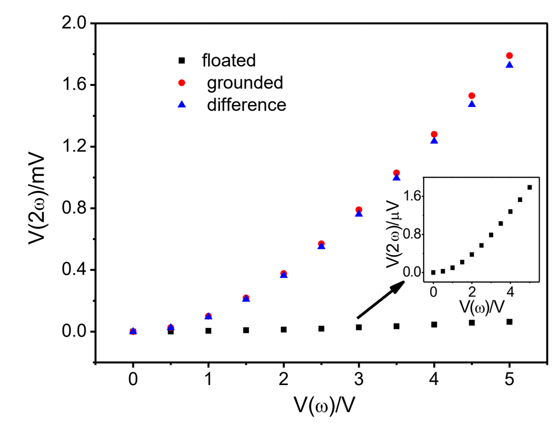
- Heater voltage at a frequency of 100 Hz induces thermal voltage at G-*h*BN-Au stack at 200 Hz measured using Lockin Amplifier

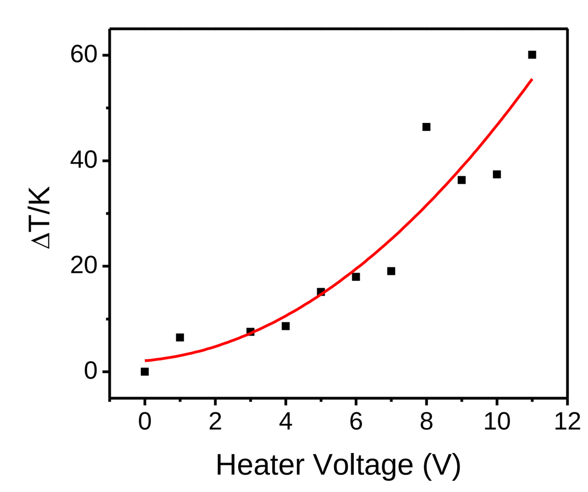


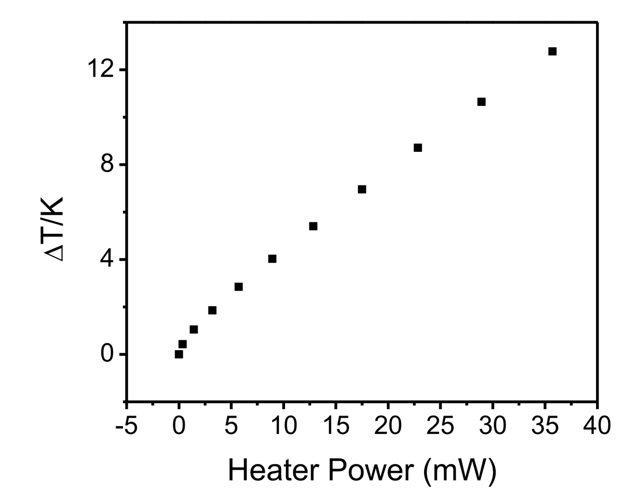
Heating Case



Non-Heating Case

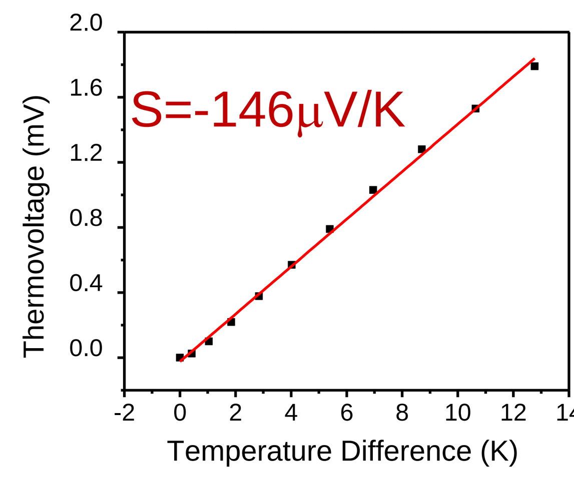


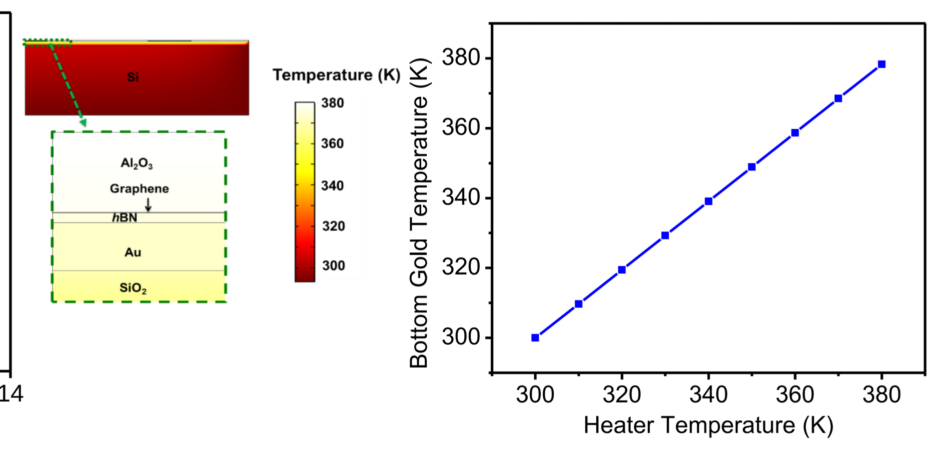




Assumption: Bottom Gold temperature Remains Constant

Conclusion

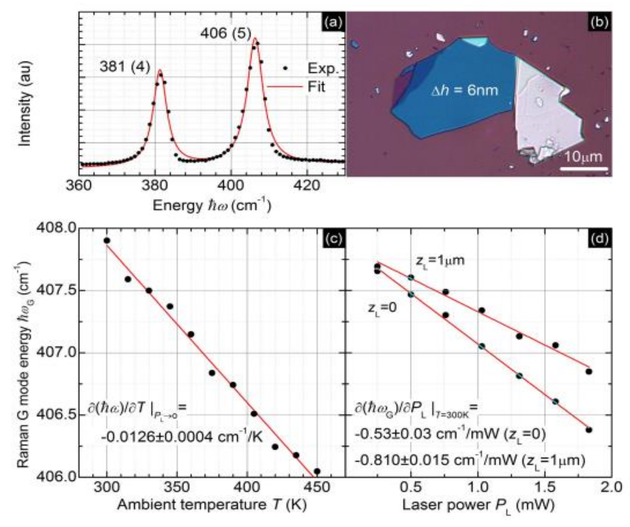




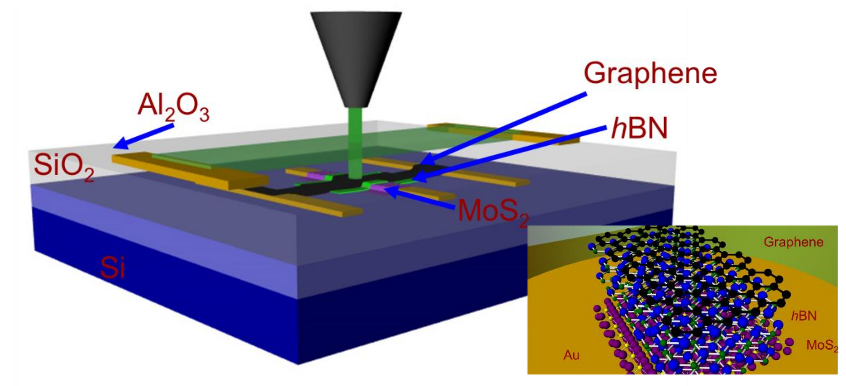
COMSOL Simulation

- COMSOL simulation indicates our assumption is really aggressive
- Underestimation of Seebeck Coefficient

Future Steps



©Judek et al.



- Monitoring Raman Downshift of MoS2 to calibrate bottom temperature

Sponsors

U.S. DEPARTMENT OF ENERGY | Office of Science

Ming Hsieh Institute
Ming Hsieh Department of Electrical Engineering