

Objective

The objective of this research is to electrically characterize graphene, a 2D material, by first fabricating gold contacts on a graphene sheet to measure sheet resistance, then fabricating graphene channels to eventually measure and calculate resistivity and electron mobility.

Graphene's unique electrical properties and its unusually high electron mobility could lead to the development of flexible, high-speed electronics.

Introduction

- Graphene is a 2D allotrope of carbon with unique electrical properties.
- The electrons in graphene are Dirac electrons that behave like massless particles of light [1].
- Being a two dimensional material, graphene is both transparent and flexible. This makes it ideal for use in optoelectronics and transparent electronics such as touch screens.



Figure 1 Flexible smartphone created in 2016 by Moxi Group, a startup in Chongqing, China

Acknowledgements

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Methods and Results

Level 1 - Measuring the Sheet Resistance of Graphene

- Raman spectroscopy was used to ensure a monolayer graphene substrate
- CAD design consisting of 50x50um squares with various separation lengths was constructed
- Electron beam lithography (EBL) was used to pattern PMMA photoresist
- Gold was deposited through physical vapor deposition using a thermal evaporator and lift off

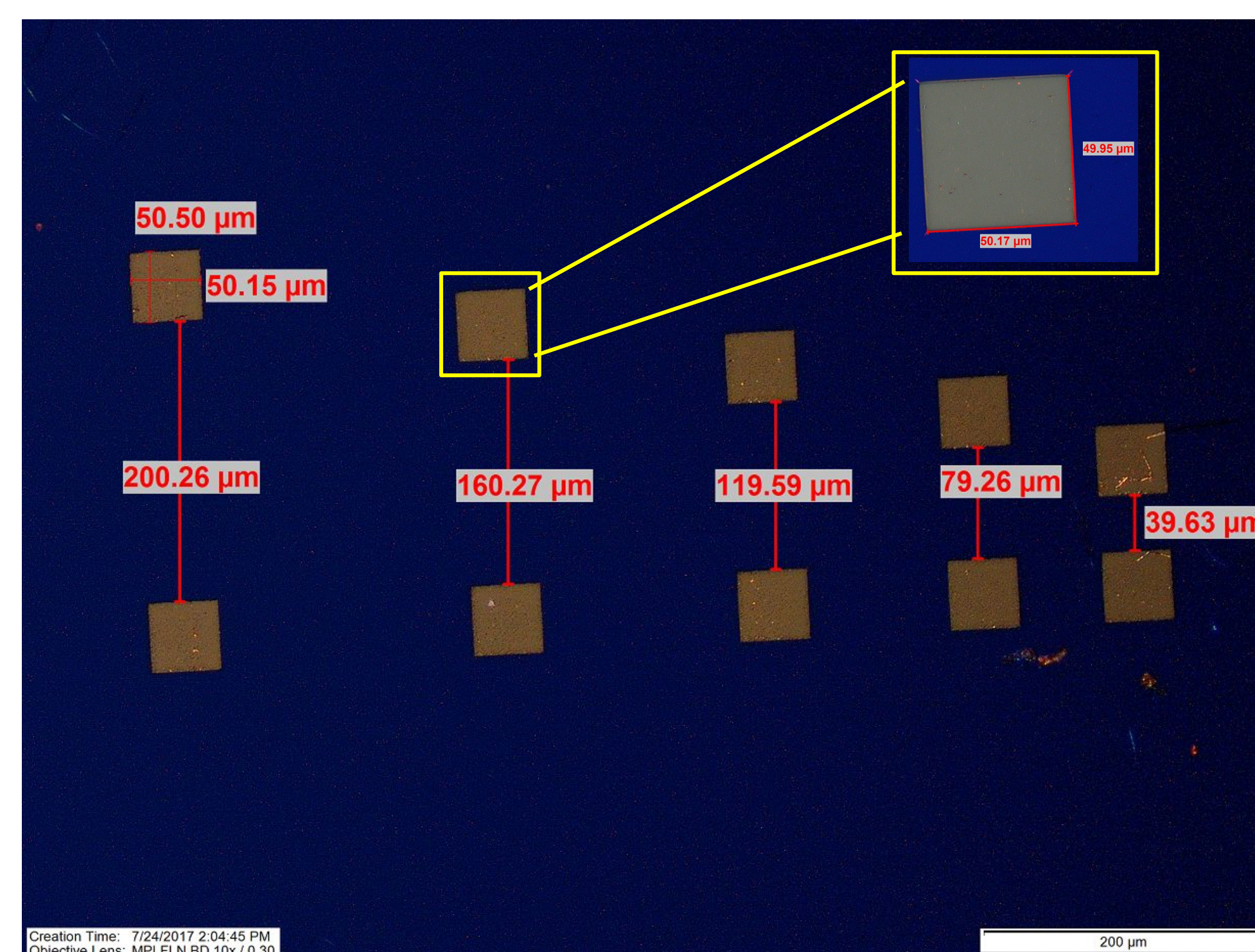


Figure 2 Gold contacts on graphene

- For electrical characterization, two point probe analysis was used to get I-V curves at different lengths
- Ohm's law was used to find resistance
- Resistance was plotted as a function of length and extrapolated to zero to get contact resistance (inconclusive)

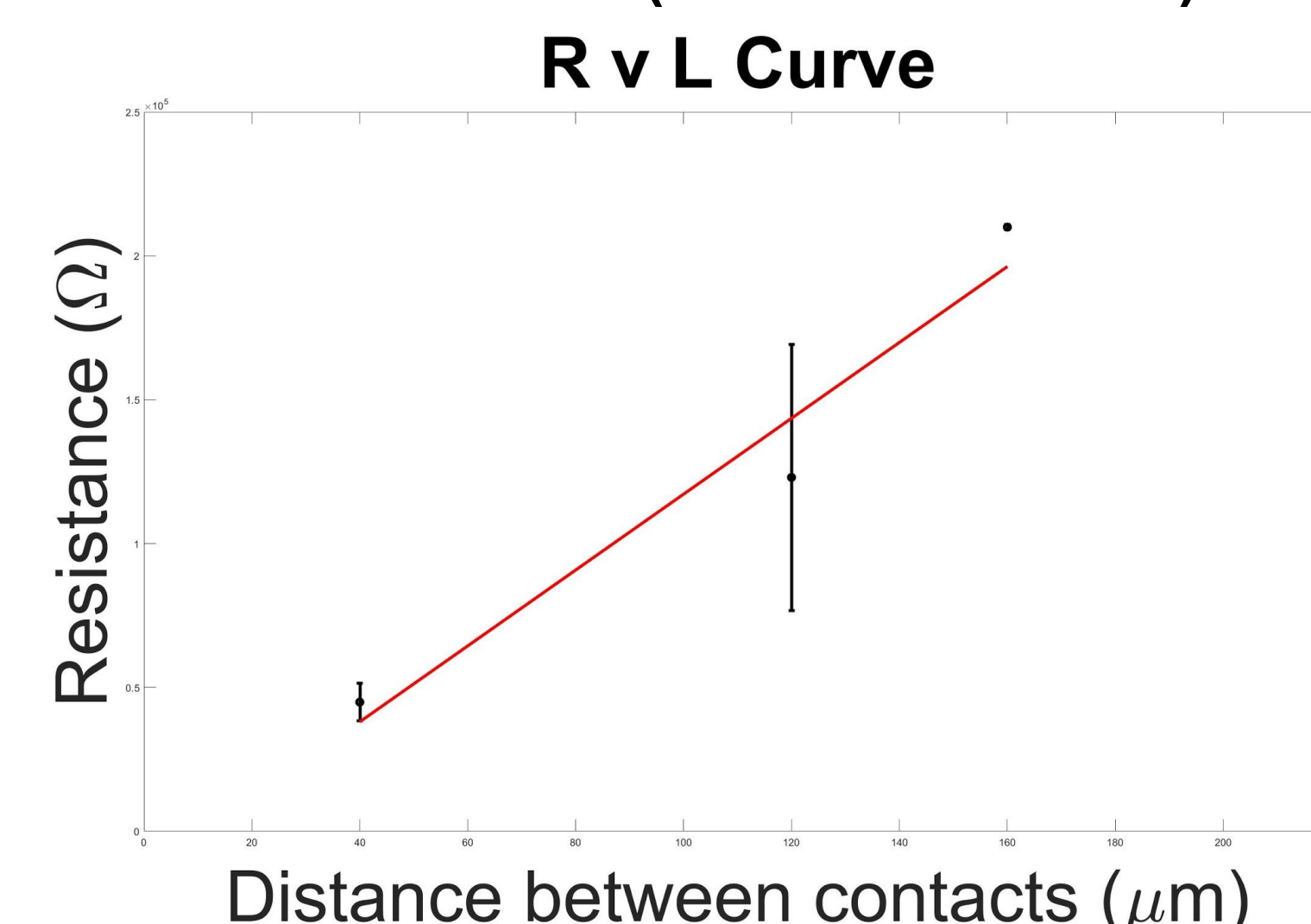


Figure 3 Resistance vs. length curve with 95% confidence intervals and line of best fit

Level 2 - Graphene Ribbons and Raman Spectroscopy

- Raman spectroscopy was used to detect the absence of monolayer graphene. It was confirmed that graphene was etched because the etched spectrum peaks matched those of SiO₂ (at 520 and 950 cm⁻¹)

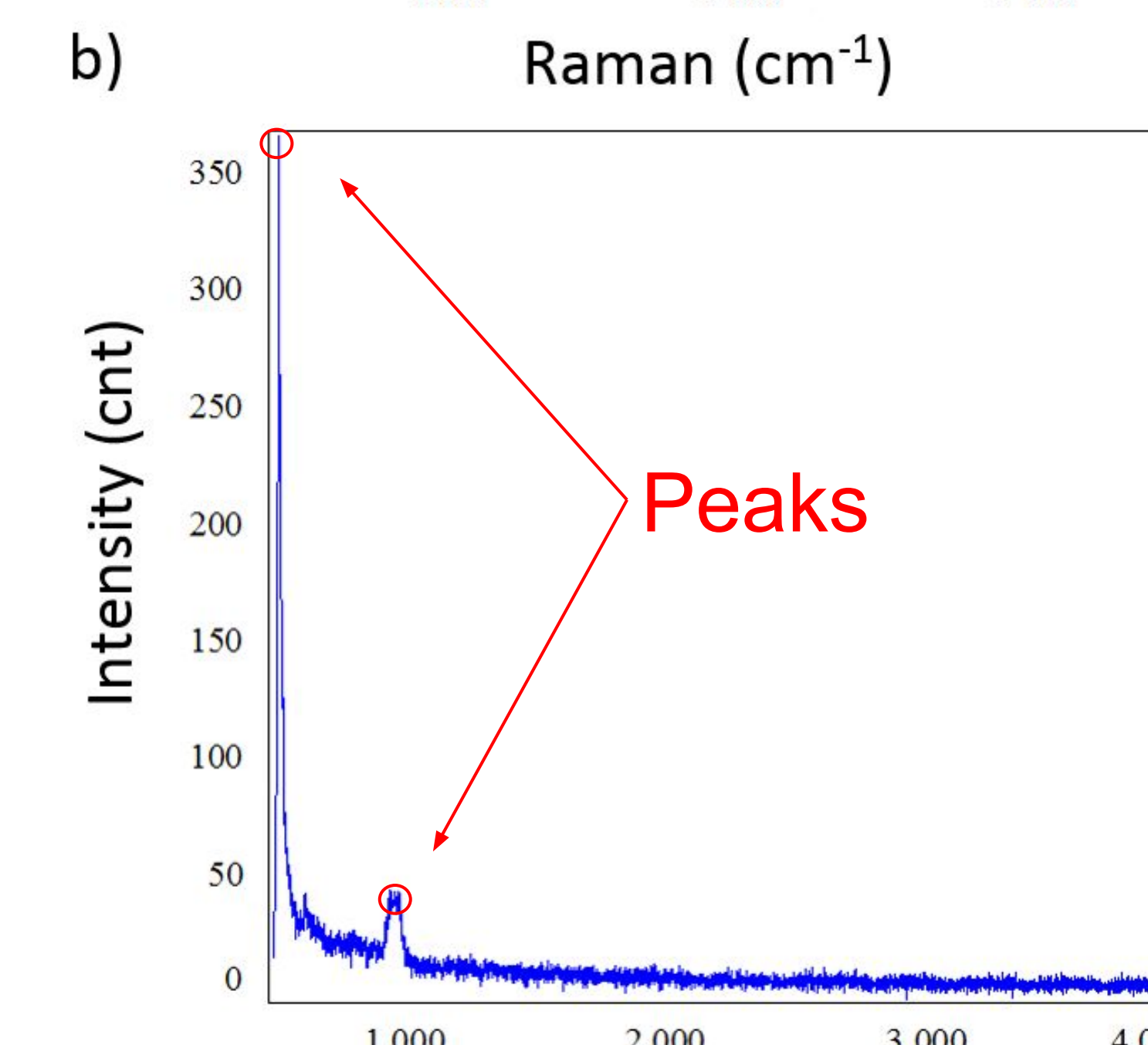
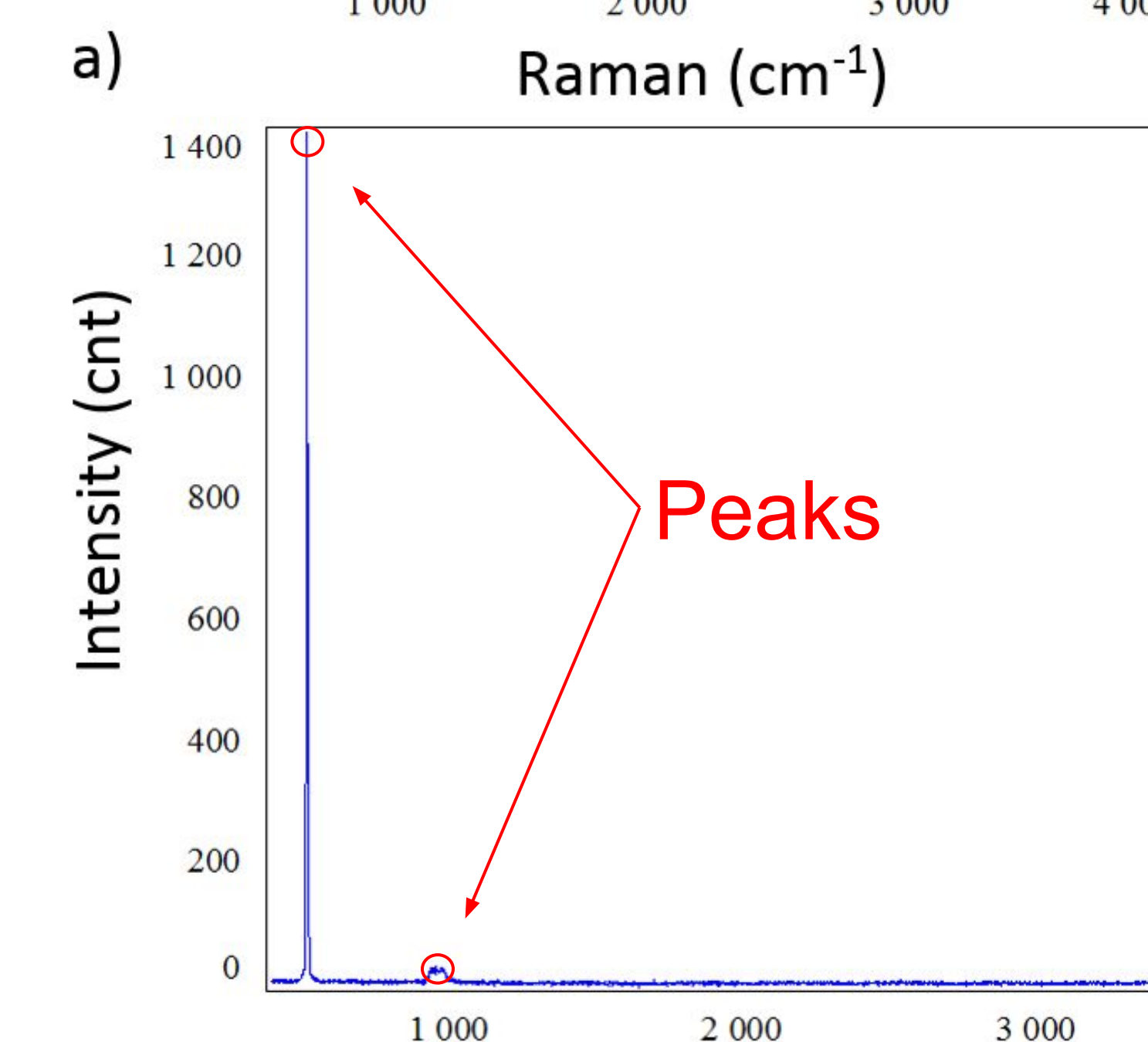
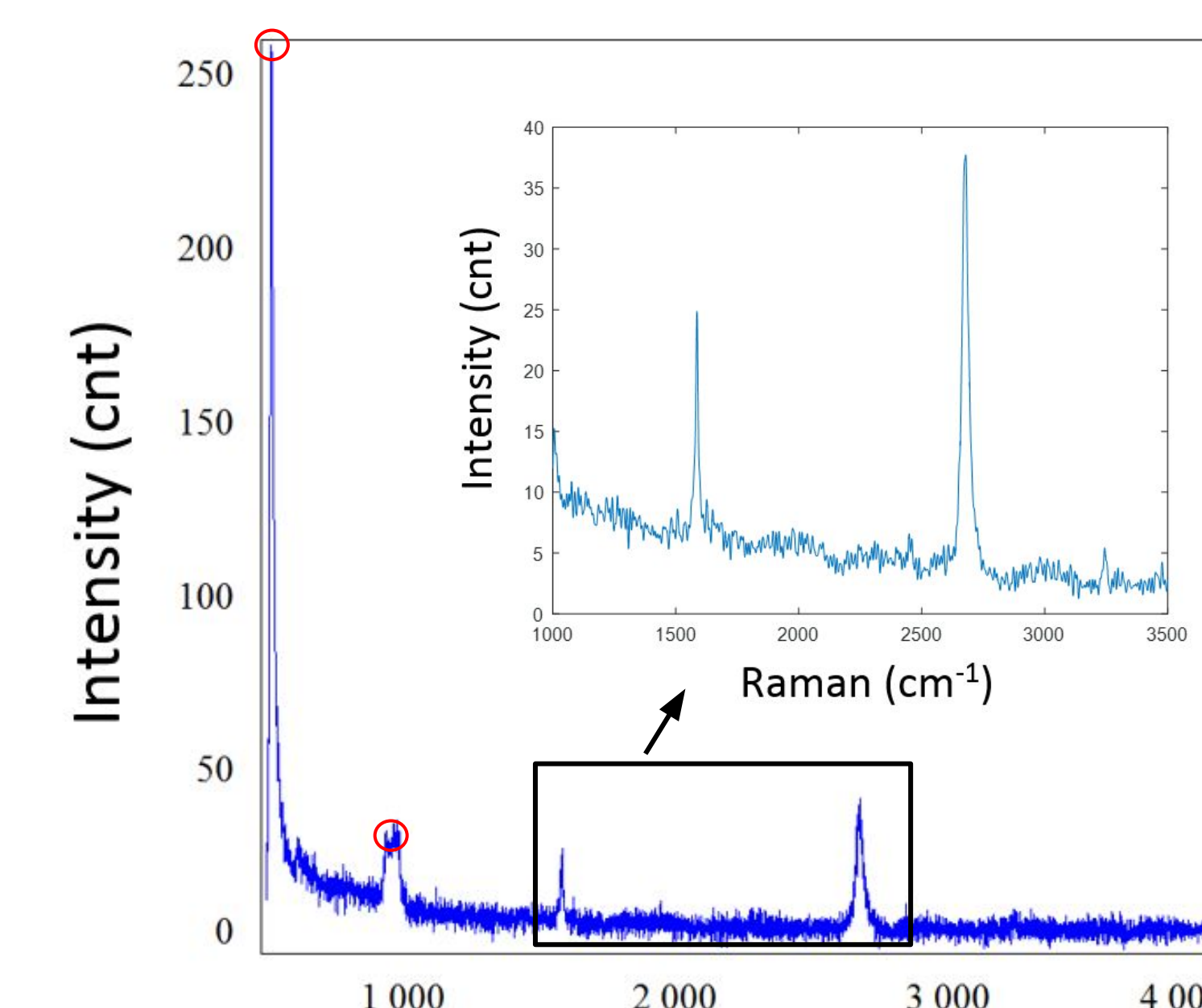


Figure 4 Raman spectrum for a) graphene substrate b) SiO₂ c) etched graphene

- To measure the resistivity of graphene, a channel ("graphene ribbon") was created for current to flow directly between contacts at different channel lengths and widths

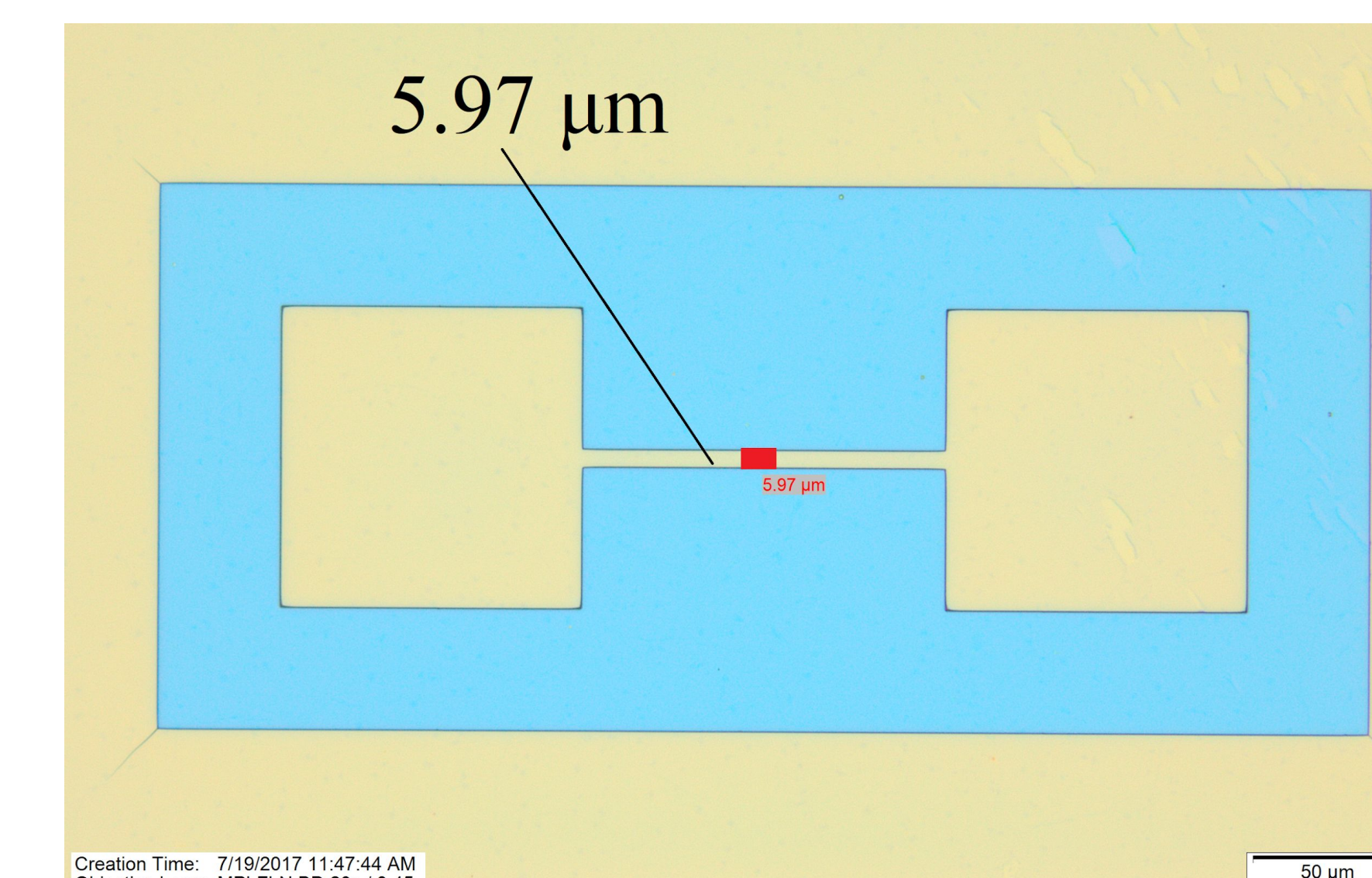


Figure 5 Optical microscope image of a 6μm wide channel with 100x100μm graphene pads after EBL and etching using AutoGlow Plasma System

CONCLUSION AND FUTURE RESEARCH

- Raman spectroscopy was successfully used to verify monolayer graphene and ensure no graphene was present in etched level 2 trenches
- Level 1 measurements were not sufficient to accurately calculate the sheet resistance of graphene
- In future studies, a second round of EBL will allow us to fabricate contact pads on either side of graphene to measure resistance and calculate resistivity and electron mobility.
- A third phase would allow the fabrication of graphene transistors whose electrical properties could be compared to modern silicon transistors in order to assess the possibility of graphene-based electronic devices.

REFERENCES

- [1] A. Castro Neto, F. Guinea, N. Peres, K. Novoselov and A. Geim, "The Electronic Properties of Graphene", *Reviews of Modern Physics*, 2009.