Methods of Improving Optical Contacting

Jennifer Hritz
Mentors: Rana Adhikari, Koji Arai

Introduction

- Need **precise equipment** to detect gravity waves
- aLIGO uses glass to suspend its test masses
- LIGO Voyager will use **cryogenically-cooled silicon**
- Silicon suspension ribbon needs **low thermal noise** and a **strong bond**

Background

- **Optical contacting** bonds two surfaces with **intermolecular forces**
- Surfaces need to be **flat**
- Better mechanical quality than any adhesive
- **Heat** and **pressure** may improve bond

(credit goes to Wizard of Vaz on YouTube)

Motivation

- How to make a stronger bond?
  - Cleaning and polishing
  - Heat
  - Pressure
- How to test bond strength?
  - Shear and tensile strength
  - Thickness of the gap
  - Mechanical quality
- What is a “strong enough” bond?

How to make a stronger bond?

- **Surface area** determines bond strength
- **Newton's rings** indicate a bond
- Needs to be **flat**
- Could introduce **heat** and **pressure**

glass slides □

silicon wafers □

□ not bonded

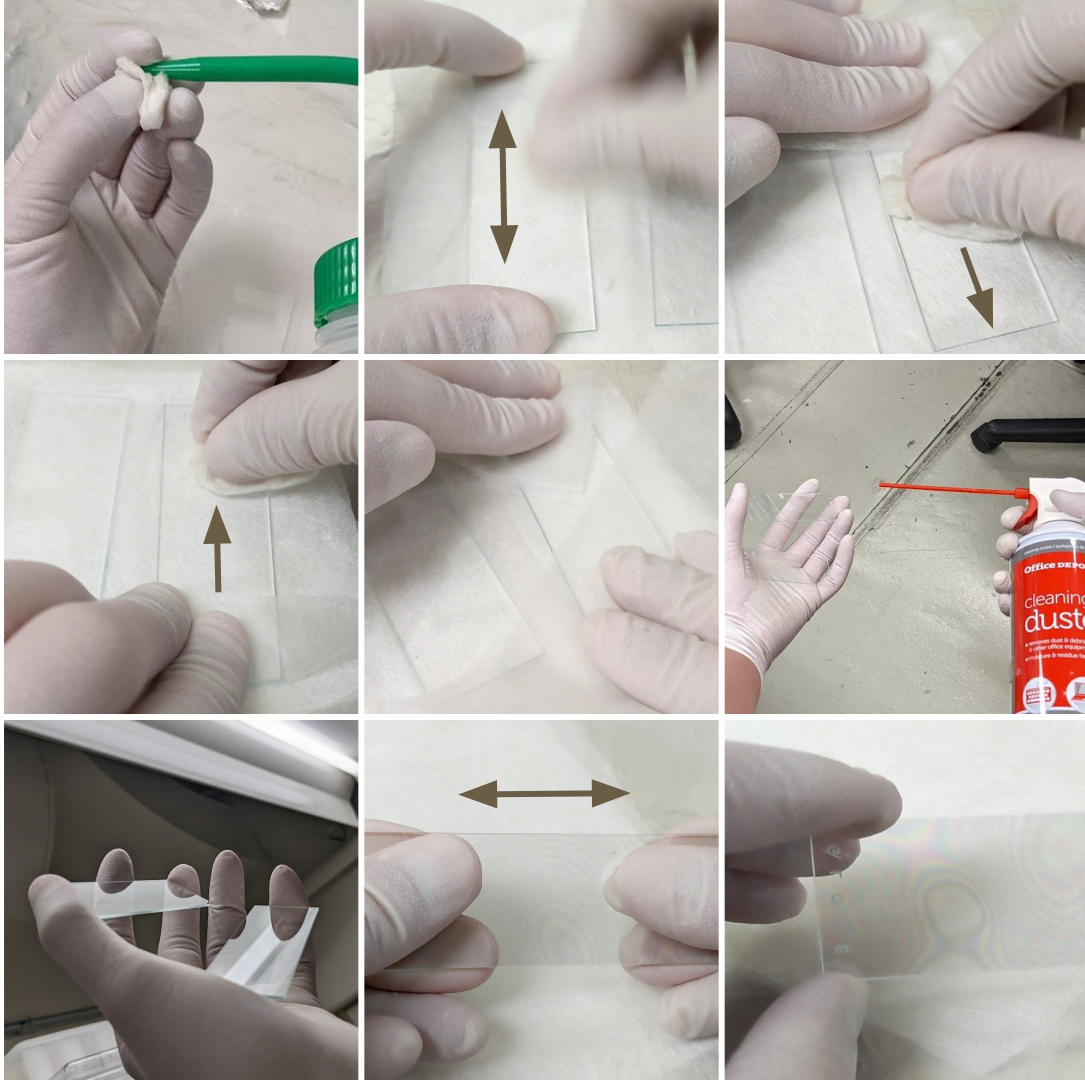
"successfully" bonded □

Cleaning

- Scrub surfaces
- Remove fibers
- Rub slides together
- Repeat until success

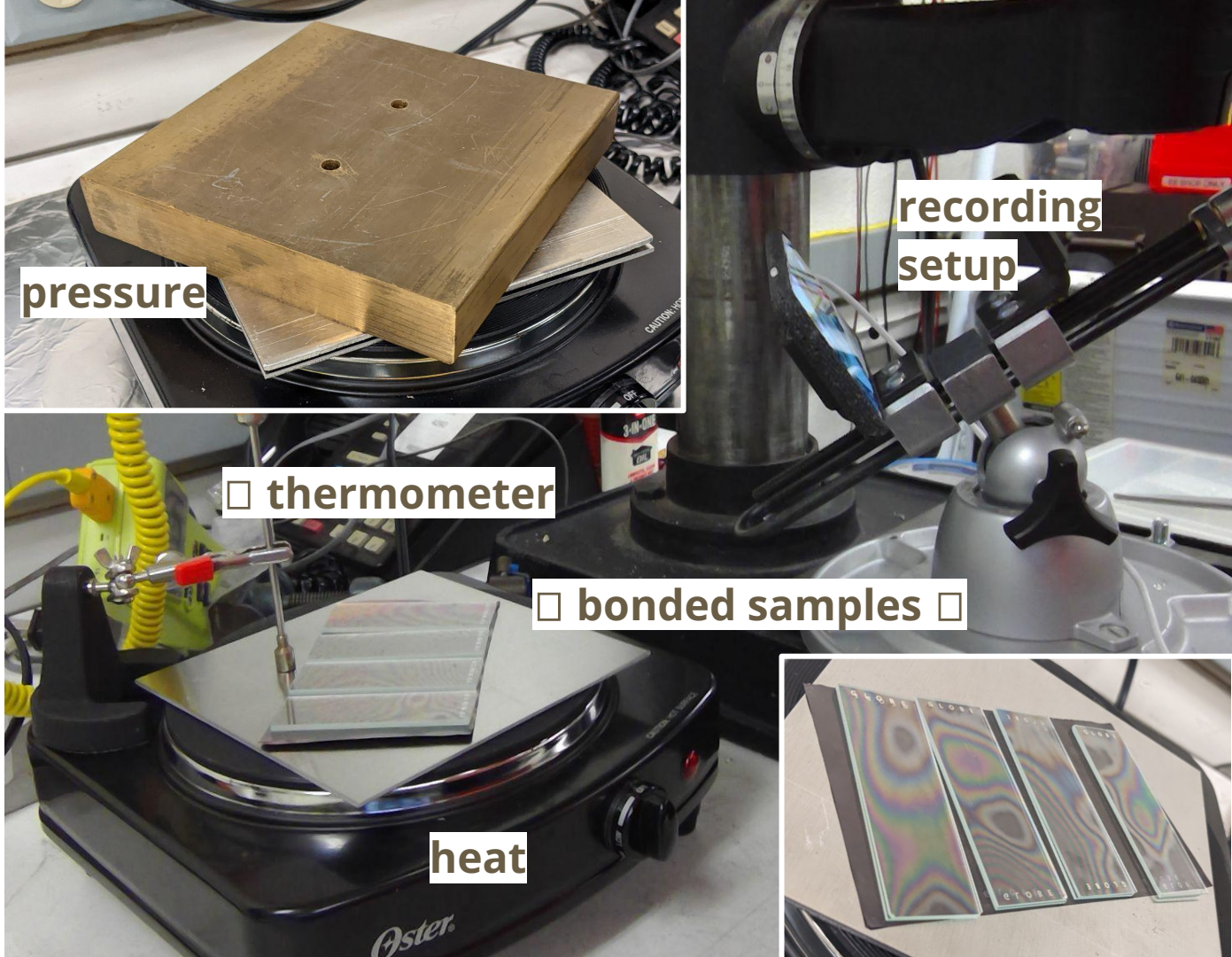
Alternatively...

- Put liquid in gap
- Wait



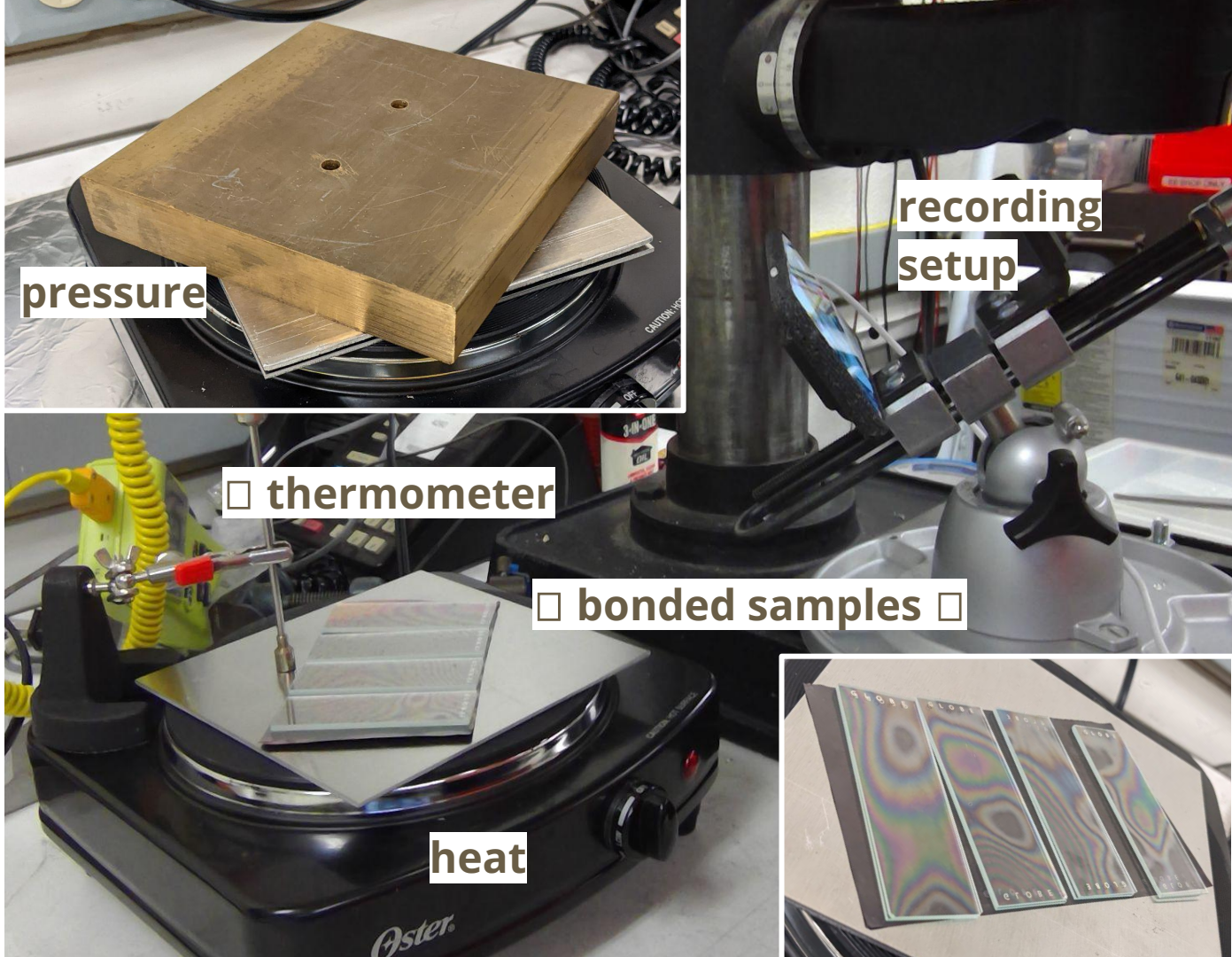
Heat and pressure

- **Hot plate** and **brass slab**
- Need uniformity
- Heating needs to be **slow**



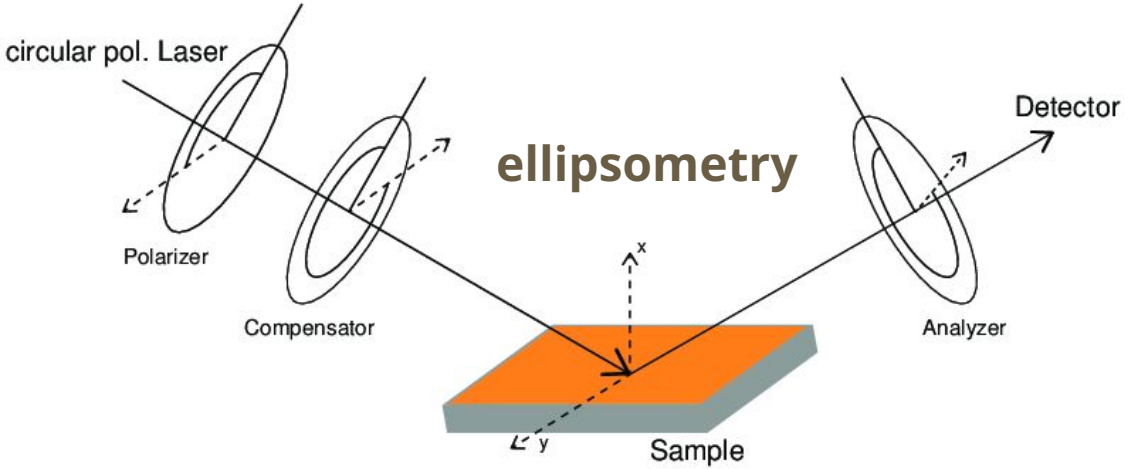
Heat and pressure

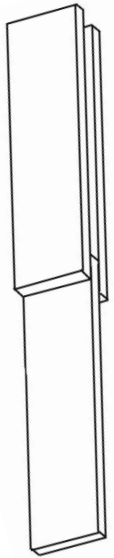
- **Hot plate** and **brass slab**
- Need uniformity
- Heating needs to be **slow**
- Pulse width modulation
- Currently **no improvement**



How to test bond strength?

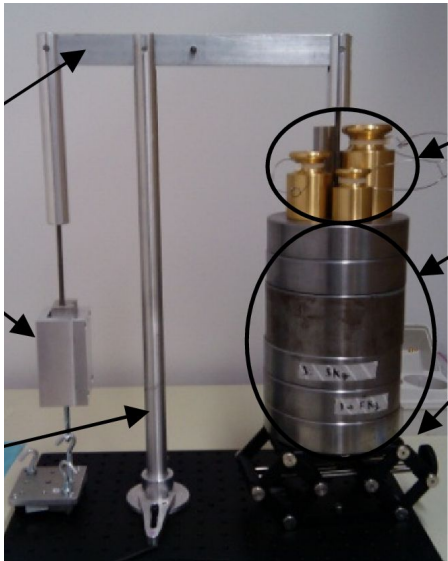
- Gap thickness using **ellipsometry**
- Mechanical quality by measuring **ring-down**
- Shear strength through **hanging weights**
- **“The Razor Test”**





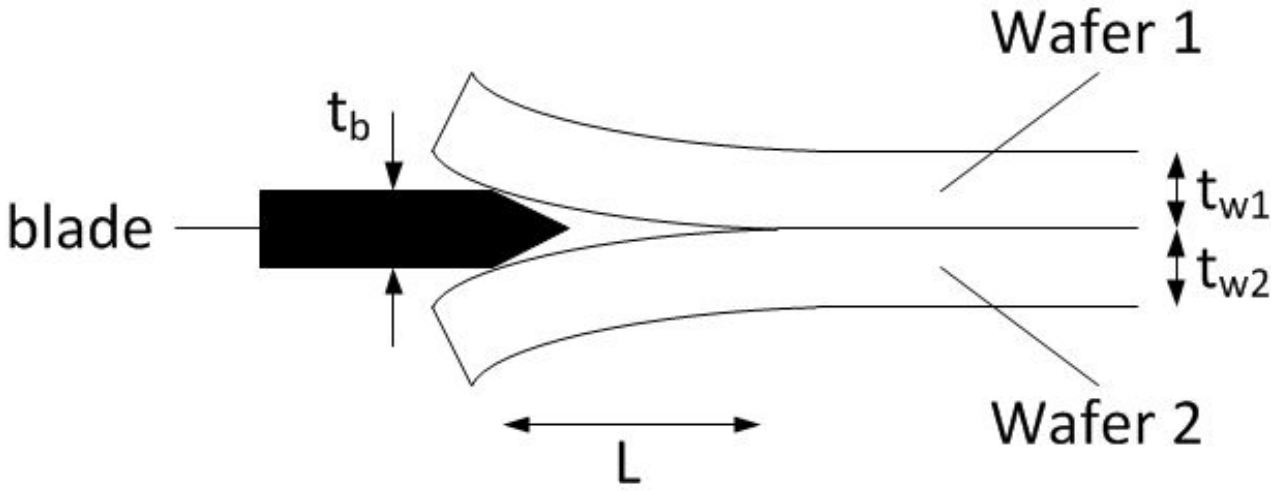
hanging weights □

□ ring-down

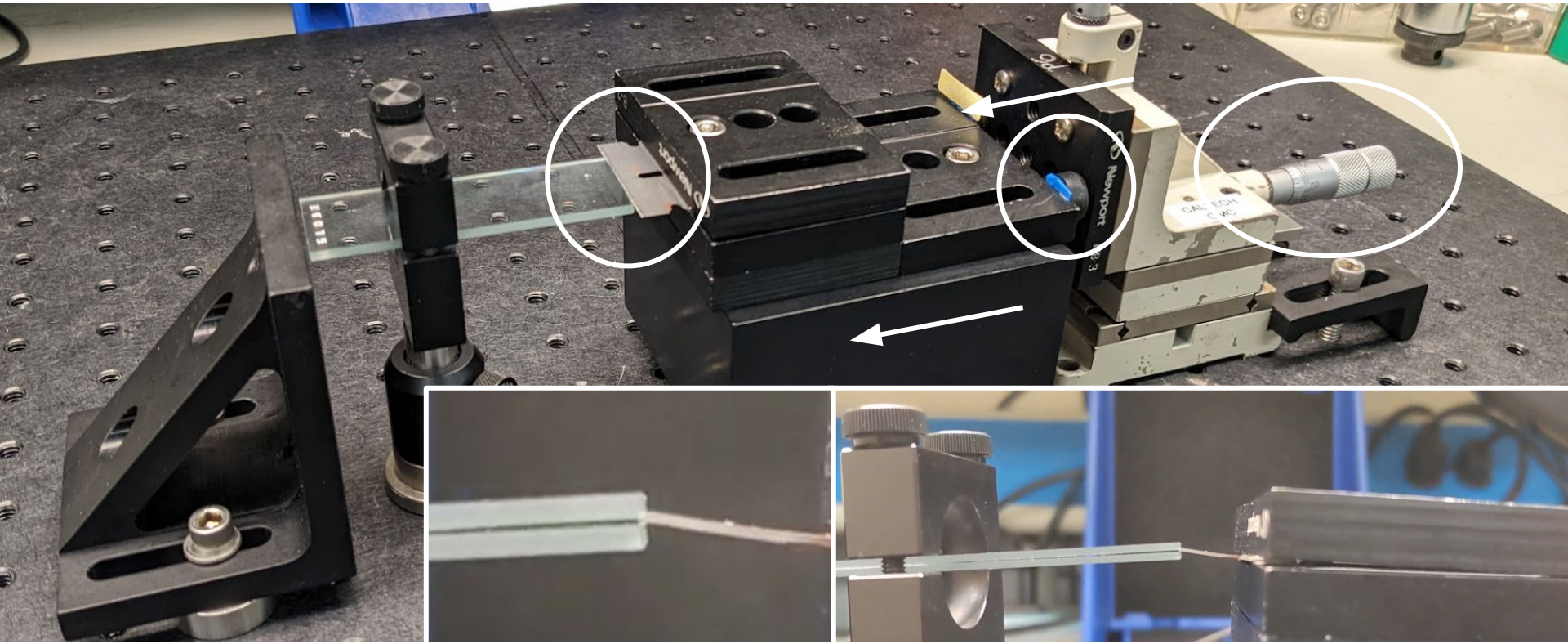


“The Razor Test”

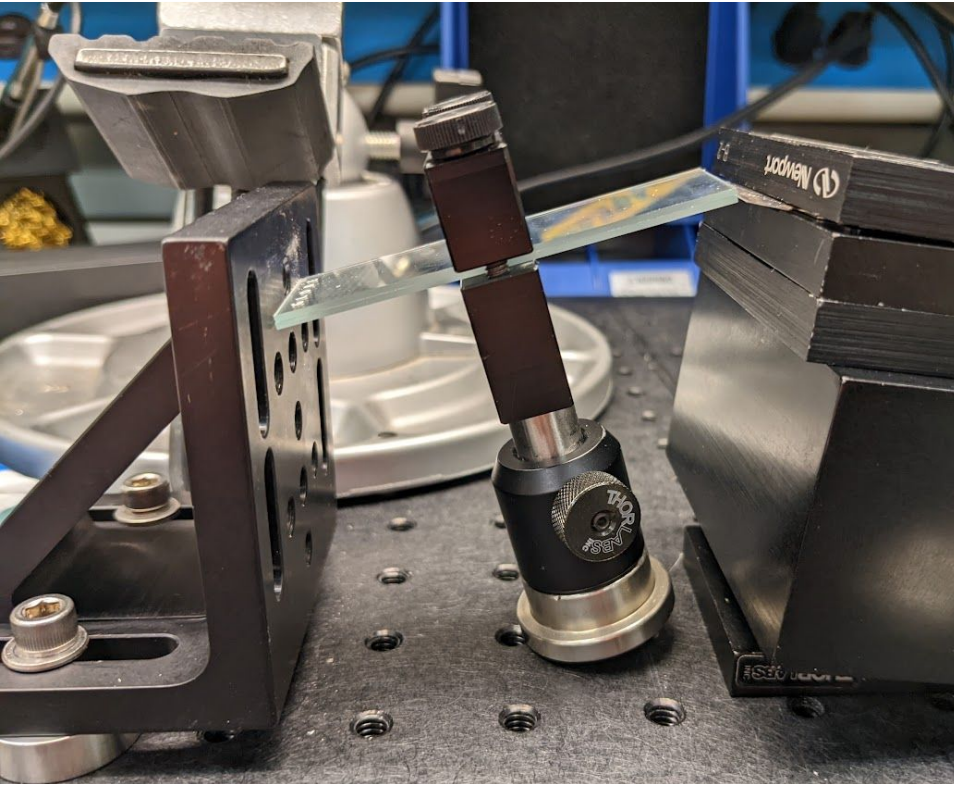
- Blade in the gap
- Lacks uniformity and precision
- Needed a way to **systematically** insert the razor

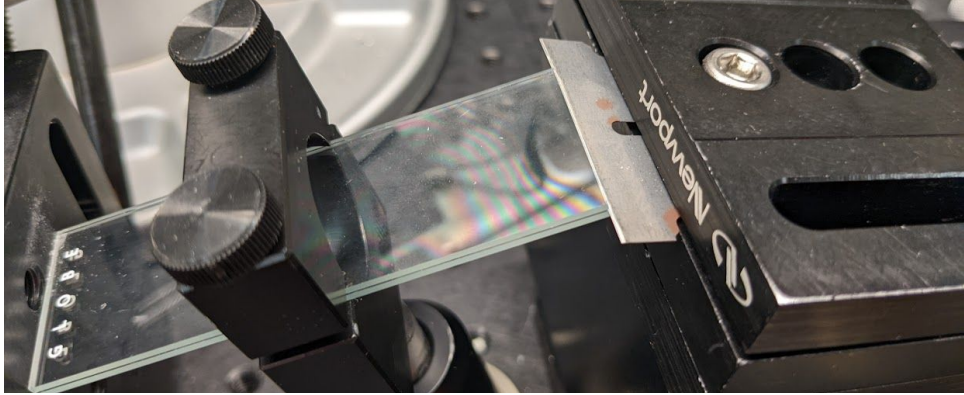


Razor test apparatus



“Results”





Future prospects

- Flatter surfaces
  - Cleaner
  - More polished
  - Higher quality
- More controlled heating
- Better strength tests
  - Improve razor test apparatus

Summary and conclusion

- **Optical contacting** is a potential alternative to adhesives
- Quantify and improve bond strength
- **Heat** and **pressure** may strengthen bond
- **Newton’s rings** and **razors** indicate strength

What is a “strong enough” bond?

Acknowledgements and sources

- Rana Adhikari and Koji Arai
- Caltech LIGO group
- SURF program
- NSF

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Thank you!

Any questions?