Optimizing Mechanical Fiber Attachment For Integrated Photonics

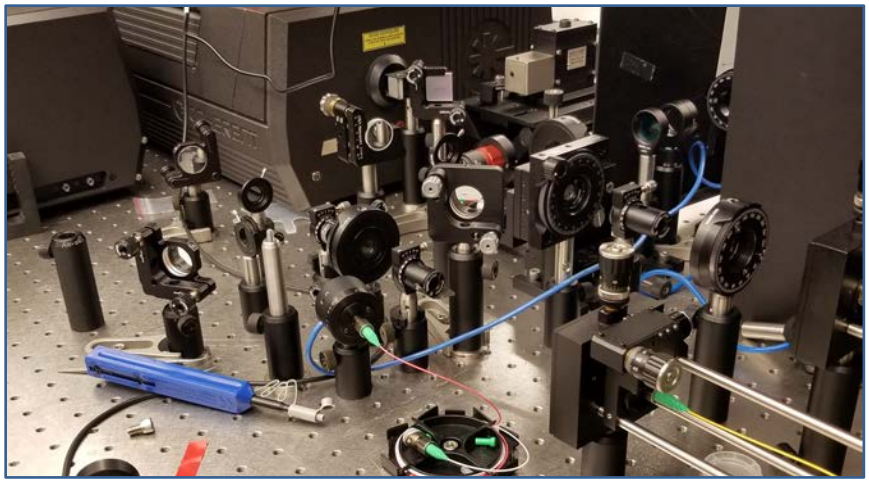
Kevin Watson

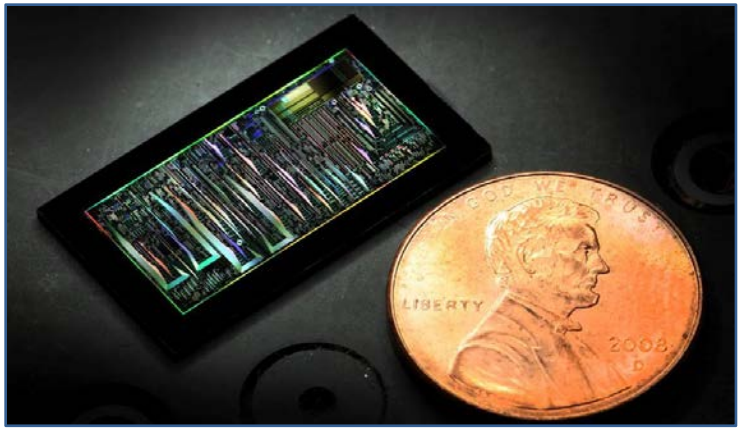
UCSB

RIT Integrated Photonics Group Stefan Preble

R·I·T

When optical components are imbedded into a crystalline structure for historically electrical tasks





University of Washington
http://www.washington.edu/news/2011/02/01/new-center-aims-to-dramatically-lower-barrier-to-making-silicon-photonic-chips/

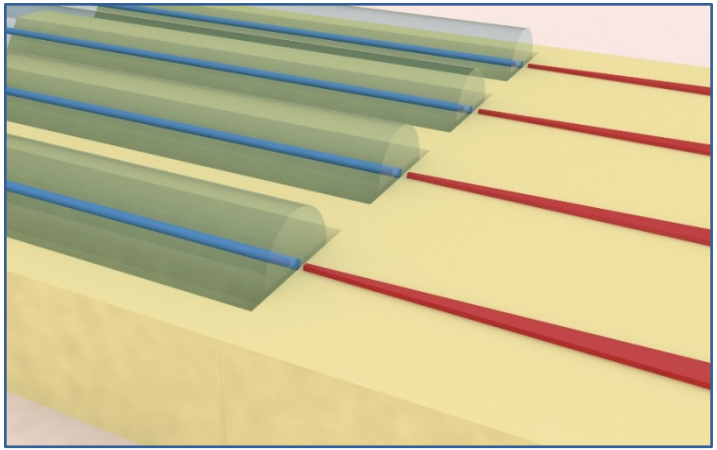
Leveraging Silicon Integrated Electronics

- Advanced Manufacturing capability's at the cost of an Indirect band gap
  - Silicon is used in photonics to harness the power of the integrated electronics industry not because silicon is an ideal material for integrated photonics. Indium Phosphide has much nicer properties
  - Normal Silicon makes for poor lasers due to a property of its structure called an indirect band gap
  - Laser light sources must be glued to the silicon or brought in externally via a optical fiber

https://aimphotonics.academy/industry/mpw-runs

Fiber Attachment

- Attaching Optical Fibers to a Integrated Photonics chip as an optical input and output source
  - U Groove is used to maximize fiber epoxy bond area for mechanical and Optical signal reliability

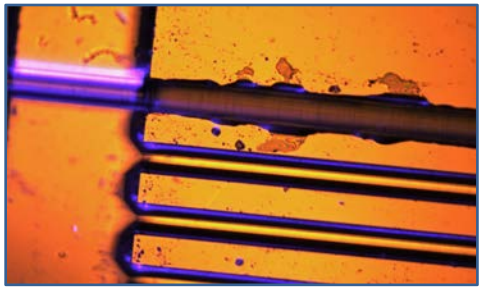


Experiment

- **Testing The Mechanical strength of fiber attachment in silicon U grooves**
  - Mechanical strength will be evaluated on max tensile force applied in line with the fiber
  - Four Epoxies from EMIUVs OPTOCAST line will be tested, these are 3553, 3553-HM, 3527, and 3554

Experiment

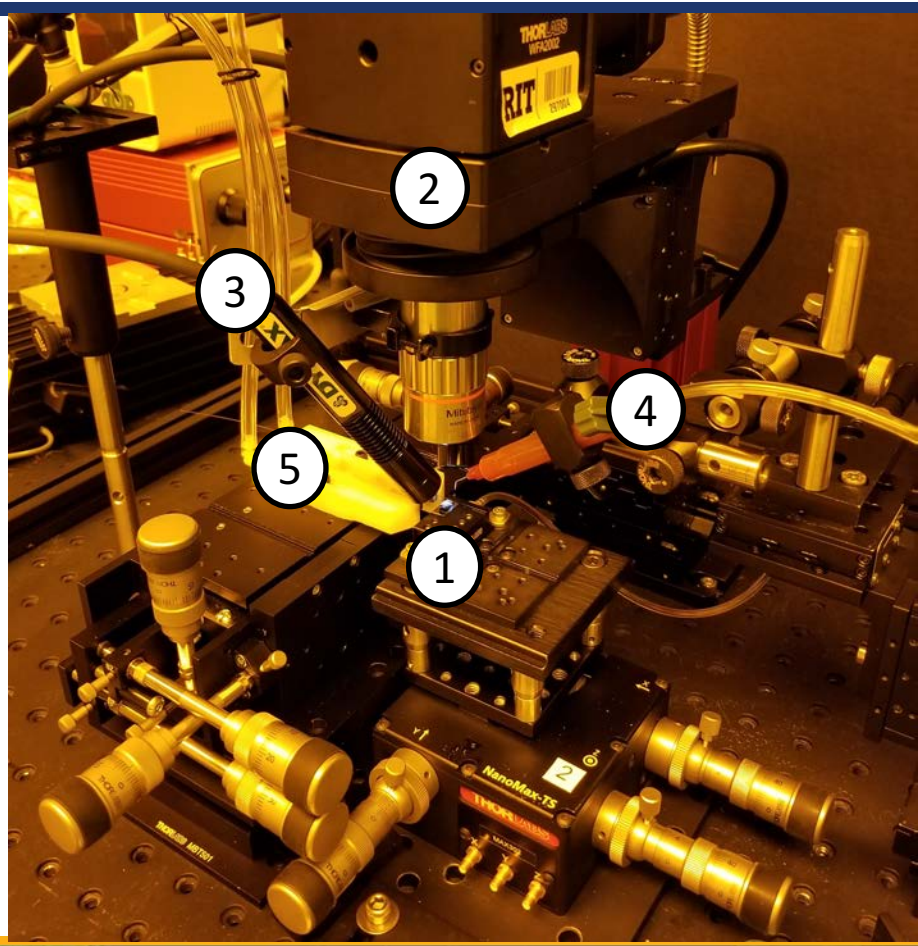
- Variable factors of fiber attachment strength being investigated for each Epoxy
  - Epoxy thermal cure time
  - Epoxy thermal cure temperature
  - Epoxy UV cure time
  - Fiber Insertion depth into U groove



- Statistical DOE is the mathematical optimization of an experiments traits to understand experimental variable relations
  - All first and second order factors of variables
  - Two way interactions between all curing factors
  - Twelve Fiber trial runs per epoxy

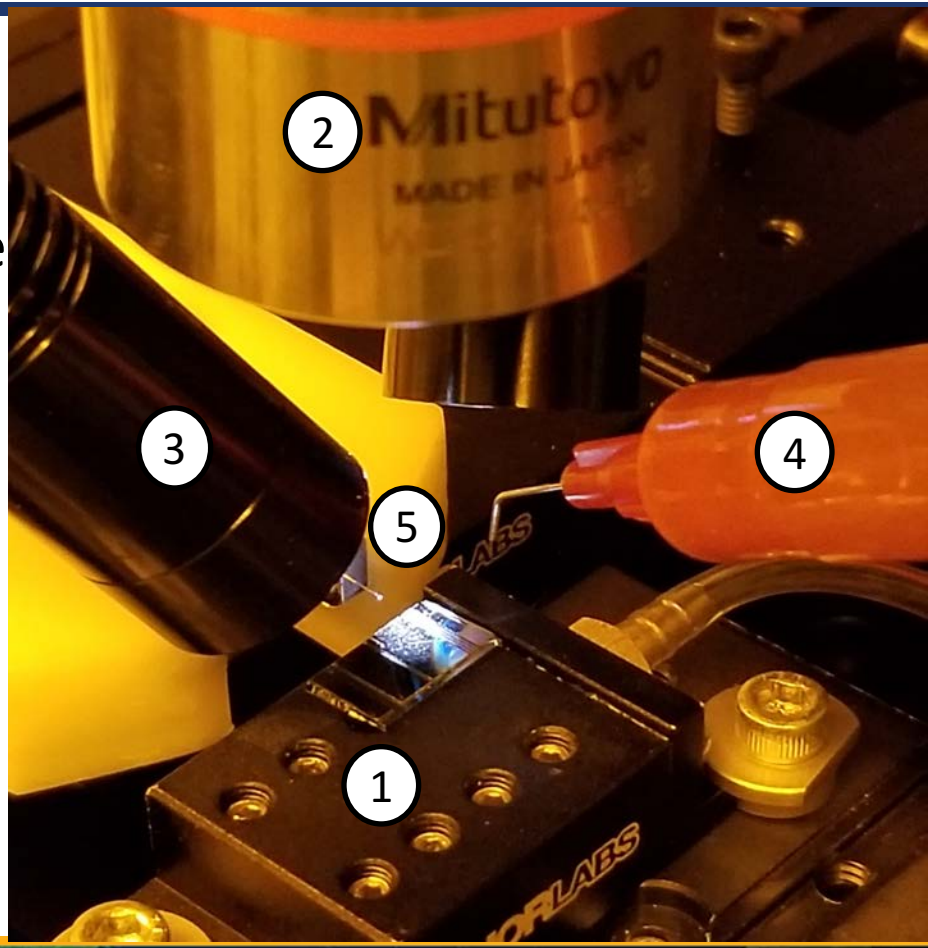
Attaching Fibers to U Grooves

- Tools of attachment
  1. U grove silicon chip is vacuumed onto center stage
     - Over the chip:
       2. Microscope
       3. UV light for curing
     - On the right:
       4. Epoxy dispenser
     - On the left:
       5. Fiber vacuum stage

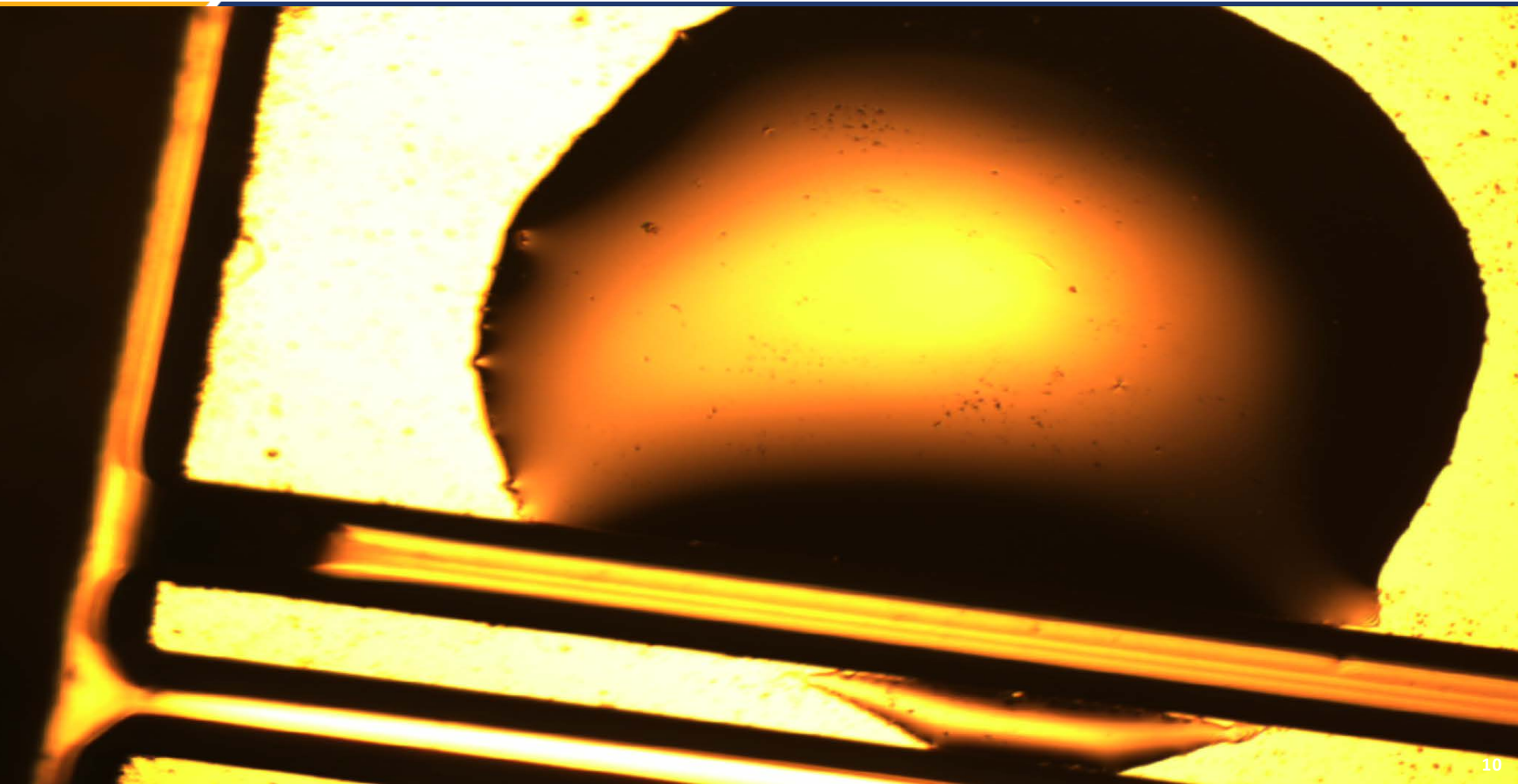


Attaching Fibers to U Grooves

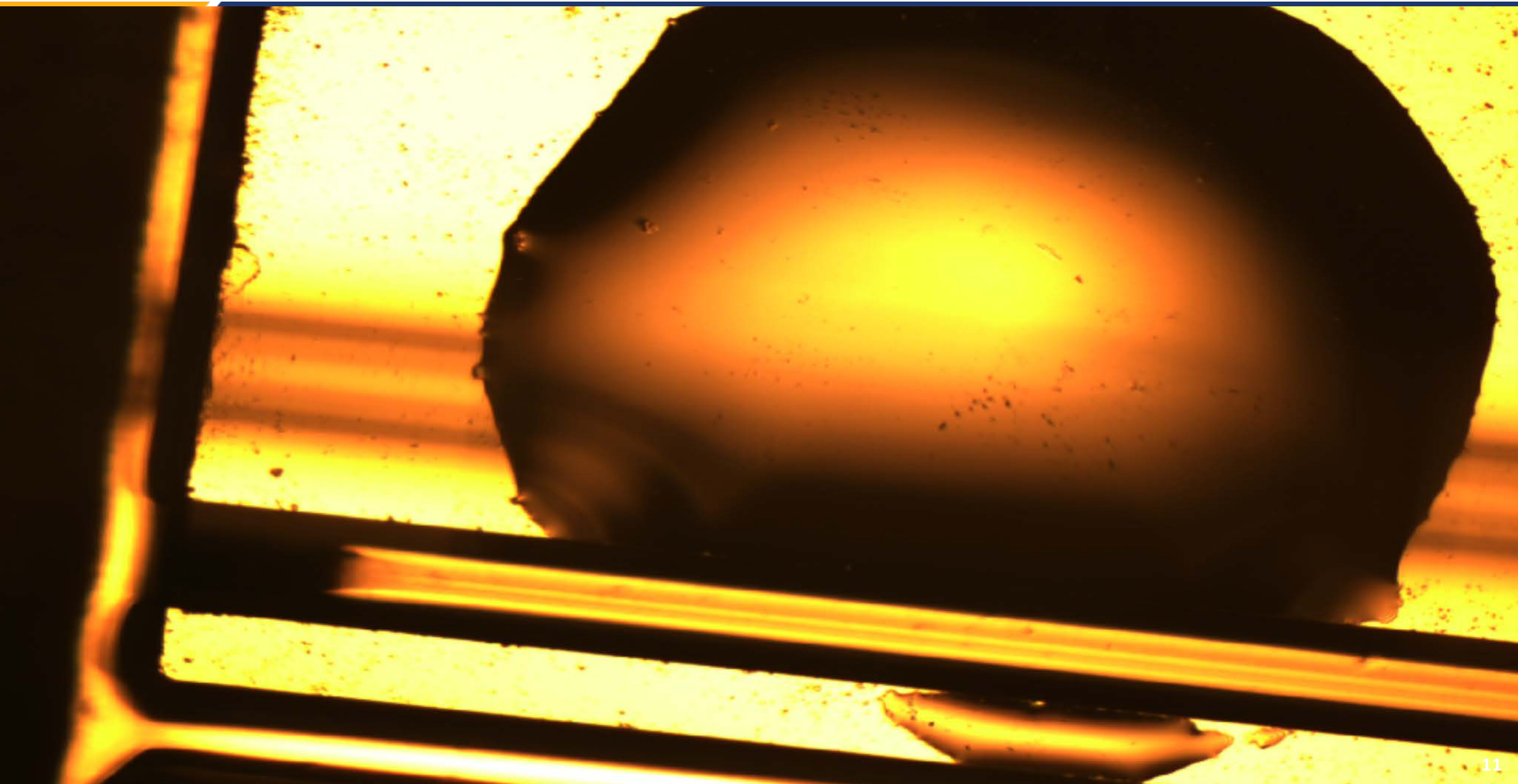
- Tools of attachment
  - (1) U grove silicon chip is vacuumed onto center stage
    - Over the chip:
      - (2) Microscope
      - (3) UV light for curing
    - On the right:
      - (4) Epoxy dispenser
    - ON the left:
      - (5) Fiber vacuum stage



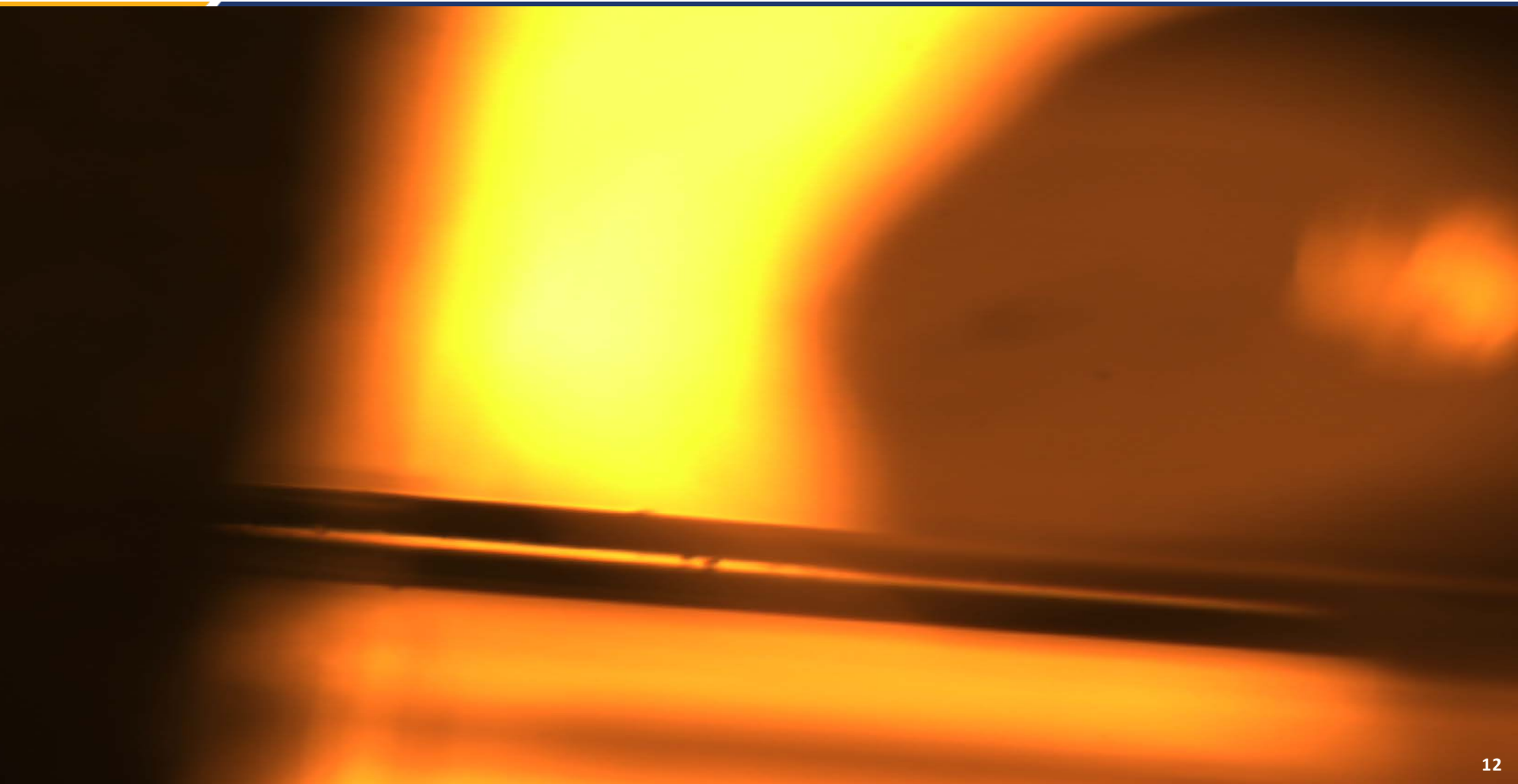
Dispensed Epoxy Into U Groove



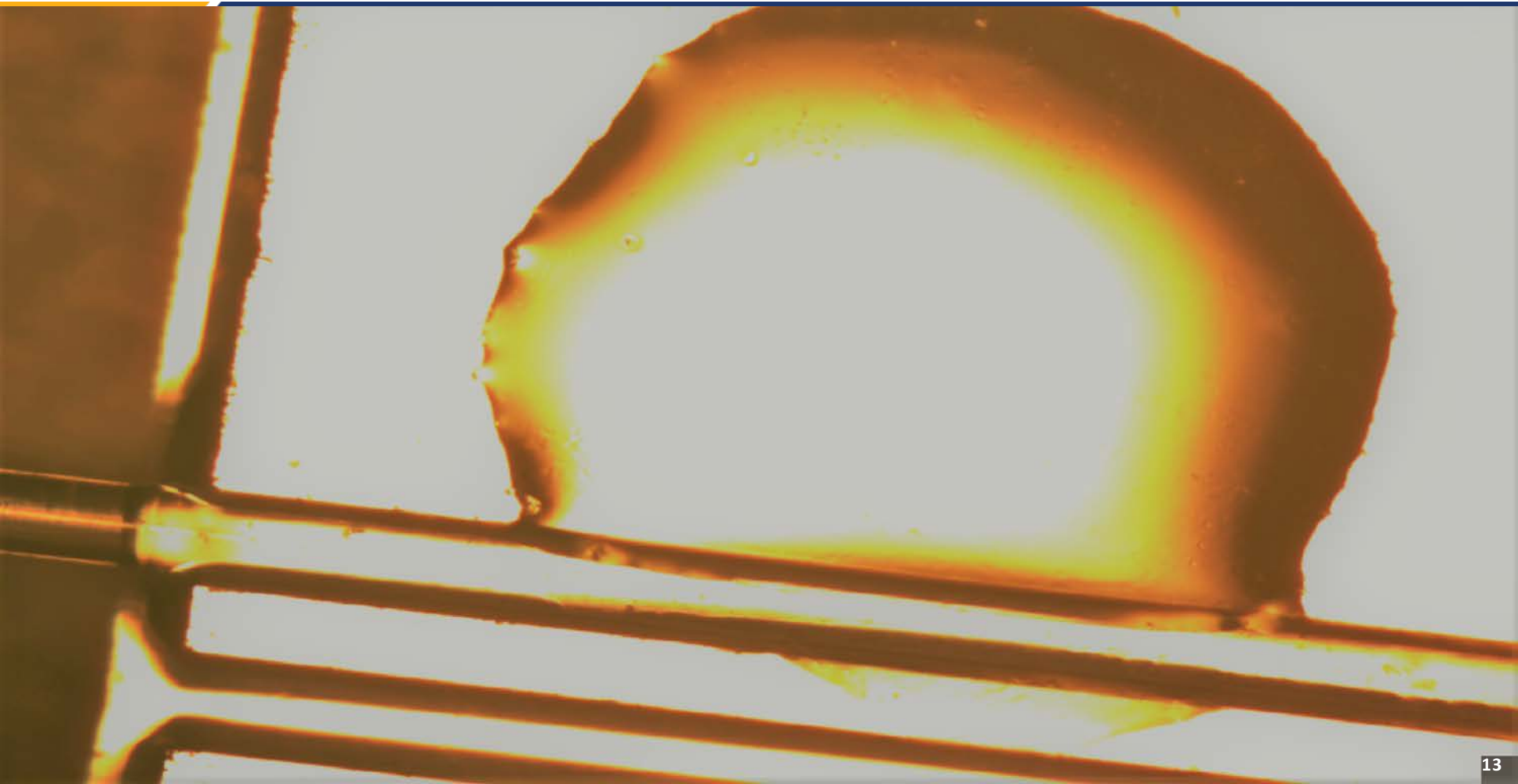
Bring Fiber Over U Groove



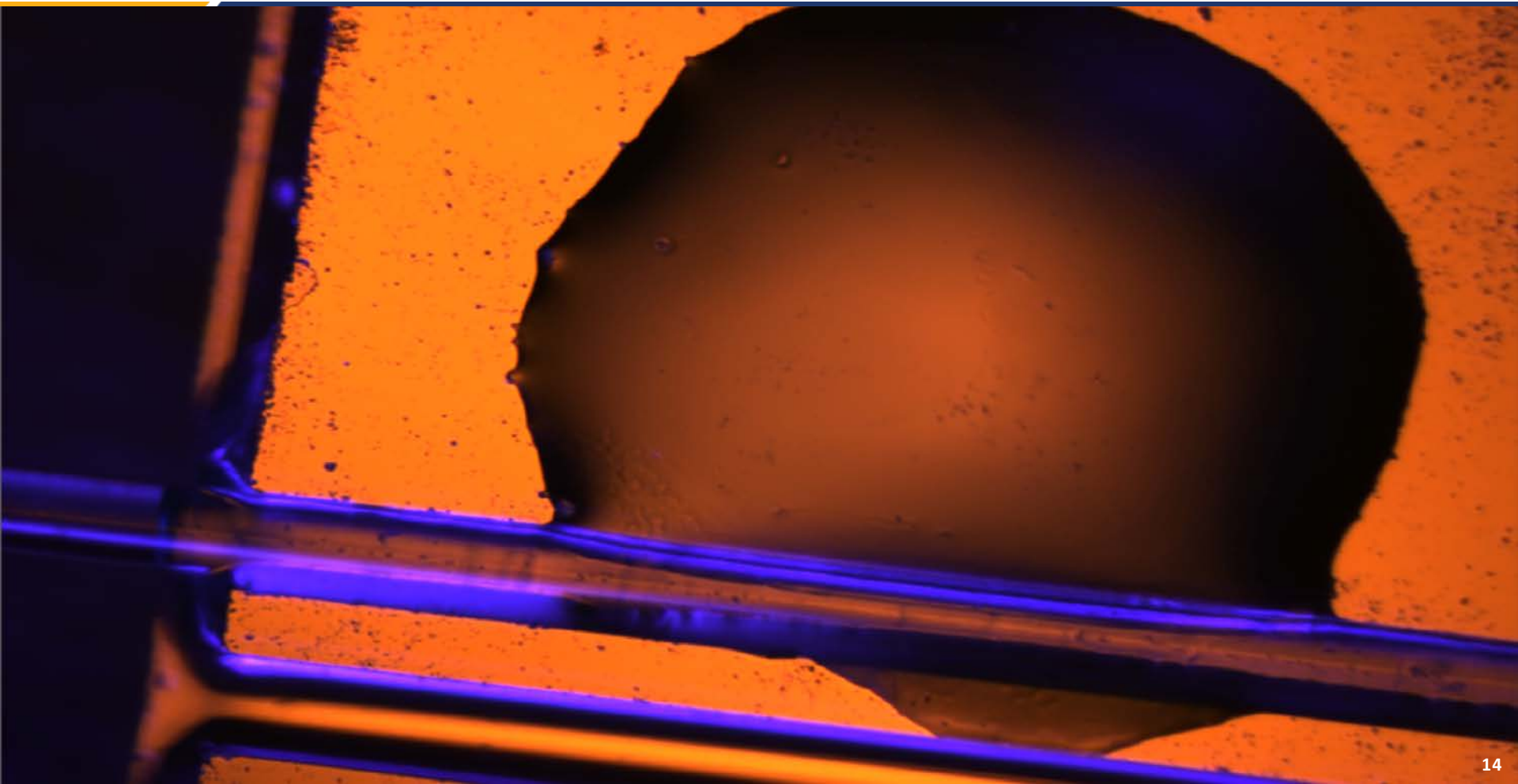
Align Fiber with U Groove



Lower Fiber Into U Groove



Expose to UV Light to Cure Epoxy



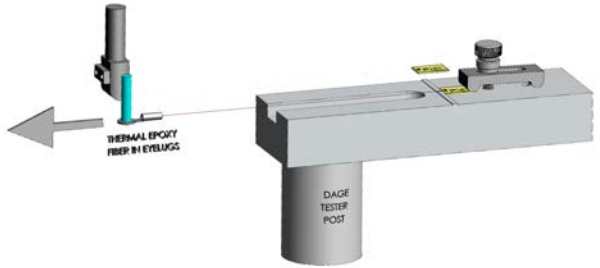
Chips ready for pull testing

Pull Tester setup

- Using the Dage Pull Tester 4000 to find force needed to break fiber attach
  - Multipurpose bond tester

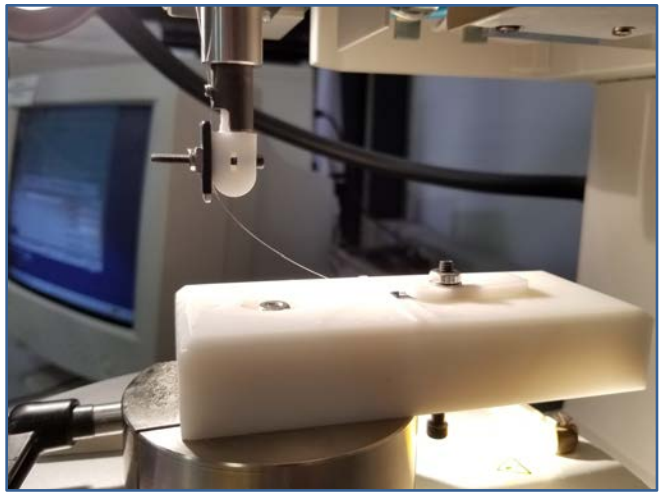
Fiber Clamp and Chip Base

- 3D printed Stage adapter holds Silicon U grove in place



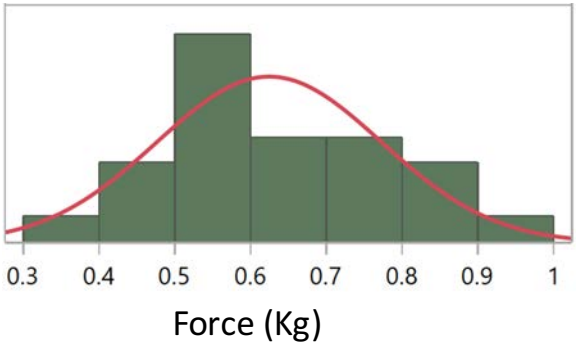
Special thanks to Thomas Palone for creating this model

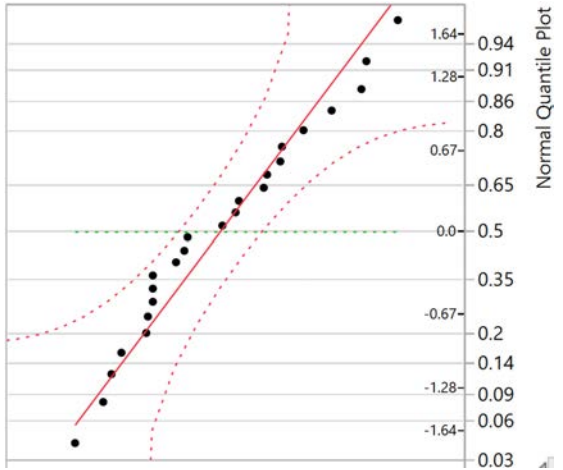
- 3D printed Fiber Clamp adapter attaches to Chuck of Dage pull tester



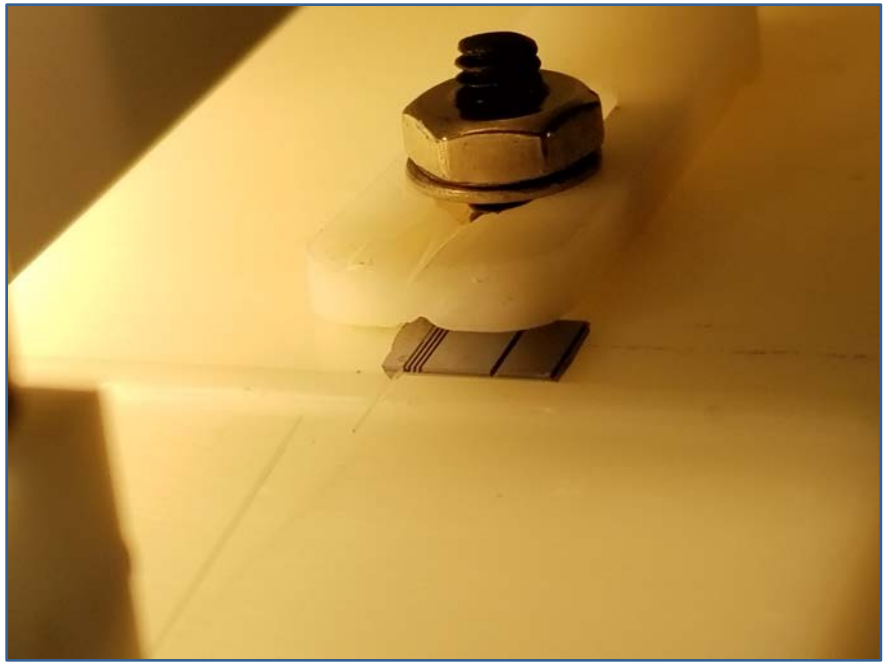
Fiber Pull Test Results

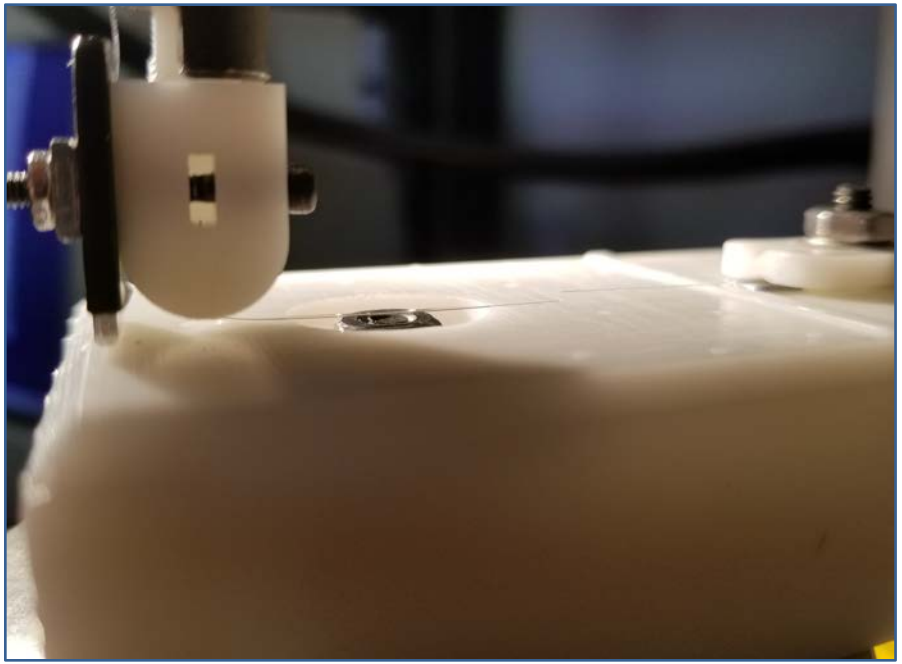
- For all 28 conducted tests the optical fiber broke before the fiber slipped from the U groove
  - This includes the expected minimum strength trials
  - Force to break fiber is normally distributed with 96% certainty
  - Mean 0.624Kg
  - Std Dev 0.149Kg





Fiber Pull Test Results





Fiber Pull Test Results

- The U grove Insertion depth can be halved without loss of mechanical property's
- Test this hypothesis further by testing different pull angles and different fiber laying methods
  - There are 20 unused samples to start further testing
  - Laying the epoxy on top of the fiber is another valuable test that will be conducted

Conclusion

- Epoxy strength exceeds expectations under minimal curing conditions
- Further testing needs to be done
- Before conducting another large scale trial smaller tests need to be conducted to better understand the boundary's of the experiment
- I could improve chip cleanliness along with improving epoxy deposition consistency

Acknowledgments

- The AIM photonics Future Leaders Program
- Thank You to Venkatesh Deenadayalan for making the used U groove chips used in testing
- Dr. Preble and the Integrated Photonics Group at RIT
- Randy Kennard for her technical assistance
- Engineers Tom Palone and Mario Ciminelli

Thank you for your time
Are there any question?