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Materials for Cryogenic Propellant Dewetting

Ethan Paulsen, Richard Zhang
University of North Texas

Jedediah Storey
NASA KSC LSP

Mai Harrison
Astrion

Presented By
Ethan Paulsen

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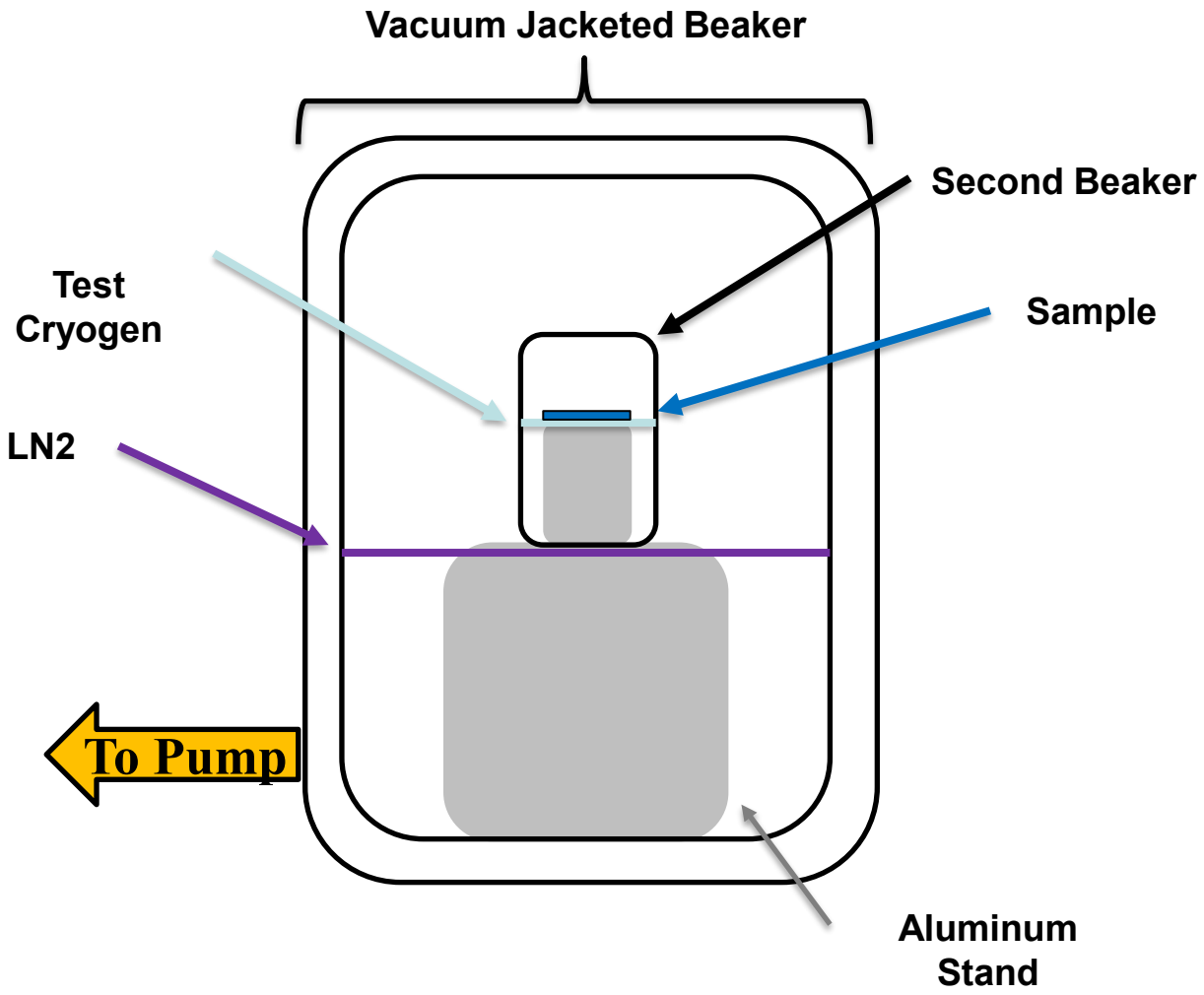
Purpose

- Identify materials for potential use in microgravity cryogenic storage and transfer
  - Surface interactions are one of the many aspects of fluid storage and management in microgravity
  - Find materials with relatively high contact angles for important cryogens
- Improve upon previous test setup
  - Focusing on droplet formation and overall reproducibility
  - Accommodate new safety restrictions for LNG
  - Reduce manual input as much as possible

Previous Setup & Limitations

- Goniometry used to determine contact angles
  - Used Canon EOS R50
- Materials are tested in a custom-built setup
  - Samples chilled and in a saturated environment
  - Individual droplets are dispensed on material surfaces
- Safety concerns
  - 15ft and 5ft clear area for LNG and LOx, respectively
  - Free of ignition sources, monitored by methane and O2 sensors

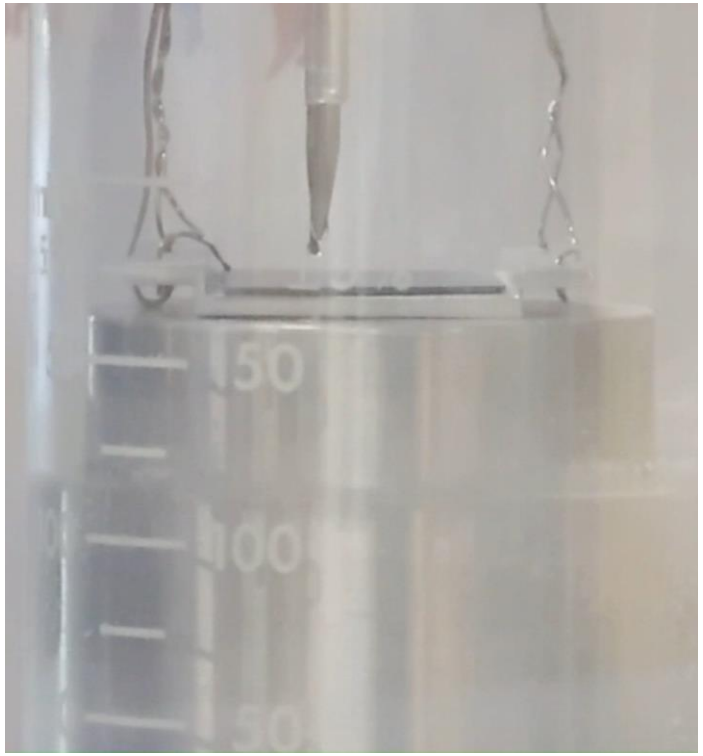


Previous Setup & Limitations

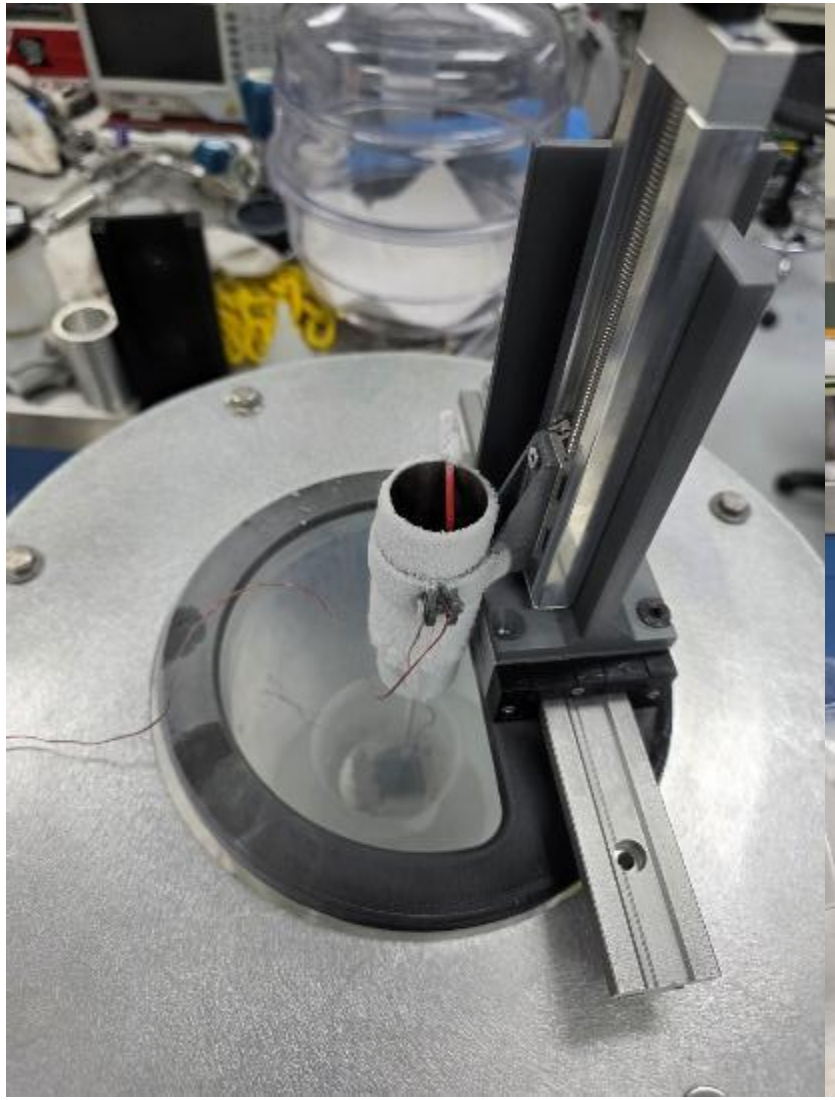
- Poor droplet formation and control
  - Previous tests were performed using a hand-crafted copper scoop
  - Droplets formed by allowing cryogen to flow through small gaps/holes
- Moisture buildup limited image capture
  - Tests were performed in Florida
  - Temperature of dewar surface led to moisture and frost buildup
- Lack of repeatability
  - Reliance on human input, especially for dispensing droplets

New Setup

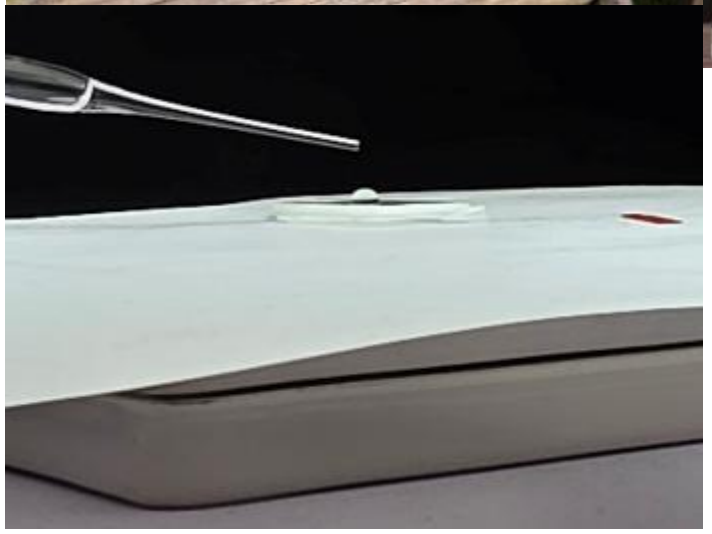
- Completely resolved most issue with previous setup
  - Consistent, repeatable droplets via a largely hands off setup without electronics
  - GN2 purge prevented moisture/frosting from previous year
- Added improvements
  - Tunable height for ideal sample/droplet distances
  - Horizontal rail to prevent test cryogen spilling onto sample
  - Improved vacuum jacketed dewar and lid design to allow easier sample manipulation



New Setup

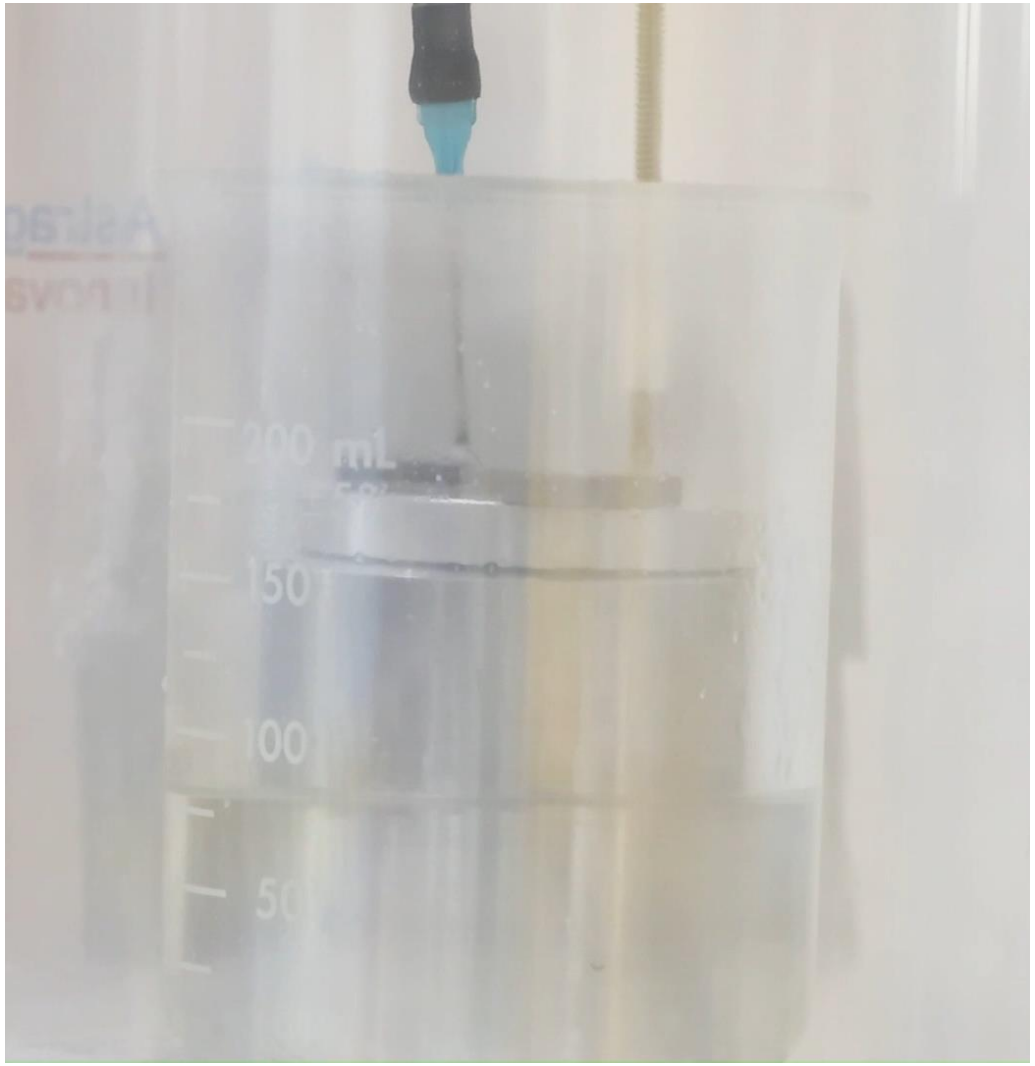


Samples



- Femtosecond laser etched patterns
  - Applied to three common metal alloys
- Coatings
  - PDMS samples
  - Metal coatings
- Hydrophobic plants
  - Lotus (Nelumbo Nucifera)
  - Caladium Hybrid
- Thin Films
  - Vanadium and Niobium oxides
  - Germanium oxides, nitrides, and oxynitrides
- Epoxy composites
  - Bare epoxy and epoxy containing silica nanoparticles

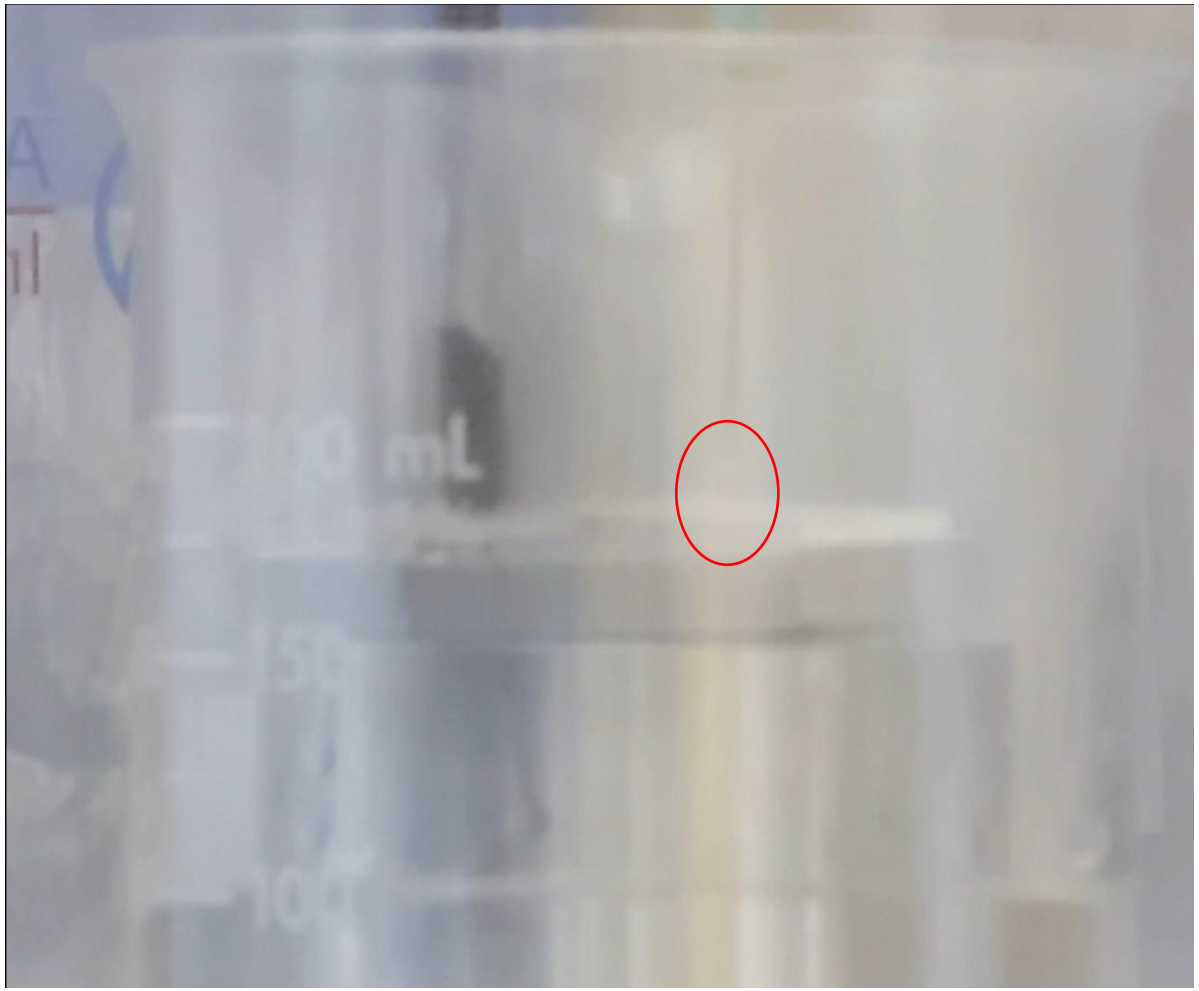
Results



- Tested 15+ samples with LNG and LOx
  - Laser etched patterns showed slight contact angle
  - Same result with LOx and LNG
  - Lotus showed similar contact angle
  - Others showed little to no noticeable contact angles
- Second round of testing planned for late August/early September
  - More than 150+ samples left to test

Results

- Issues now primarily with image capture
  - Clear area for LNG prevents adequate camera placement
  - PPE requirements limit how many available people to run the tests
  - Using LN2 leads to LNG and LOx condensation forming on the beaker
- Looking to work with KSC Advanced Imaging and Analysis Lab
  - Improving camera/lens quality
  - Proper lighting
  - Dedicated camera operator



Conclusion

- First round of testing showed no promising materials
  - Only a handful of the 200+ samples were tested
  - Some of the most interesting excluded while first trying out the setup
- New version of setup is effective for testing interesting surfaces
  - Most limitations are easy to address
  - Biggest issues are inadequate image quality and lack of samples
- Next tests will involve even more of the most promising materials
  - Both plant samples and additional laser etched patterns are planned
  - Additionally looking at MOFs and other tunable materials