NanoSonic, Inc.
nanotechnology at work

3D Printed Bimetallic Structures for Radio Frequency Devices

PI: Dr. Jennifer Lalli

2025 SBIR/STTR Exchange PI Meeting
July 29-30, 2025
Sponsored by the Department of Energy Office of Science, Office of Nuclear Physics

U.S. DEPARTMENT of ENERGY

TPOC: Dr. Michelle Shinn

NanoSonic, Inc.
nanotechnology at work

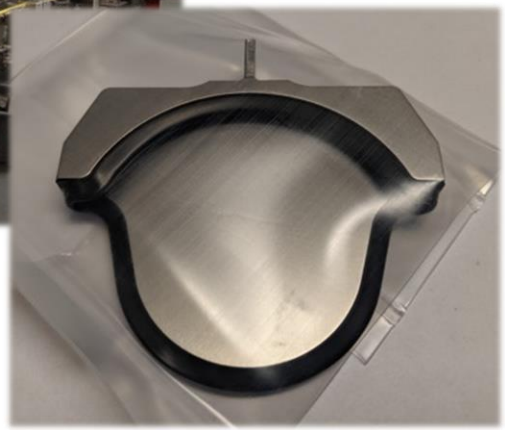
Small Advanced Materials Company
- Incorporated 1998
- Green development and scaled production
- Polymers, composites, and sensors
- Commercialized >15 SBIR derived technologies

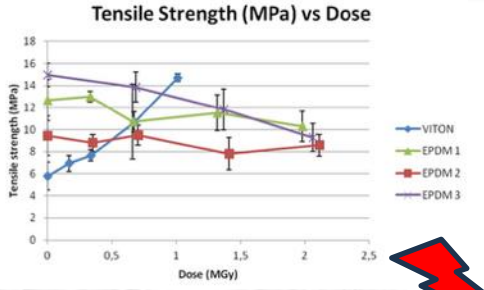
Wheatland EcoPark, in Pembroke, VA
LEED certified, energy-efficient, green building

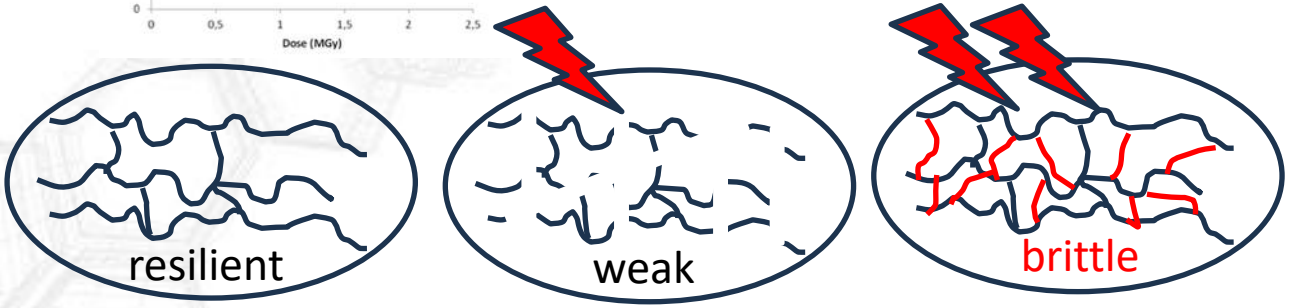
WHEATLAND ecopark

Overview

Topic 34a: Materials and Components for Radio Frequency Devices







- ***Radiation tolerant seals*** for particle accelerators – 12 GeV
- Current **Viton Seals degrade** and evolve HF
- 53 Cryomodules at JLab gate valves get replaced

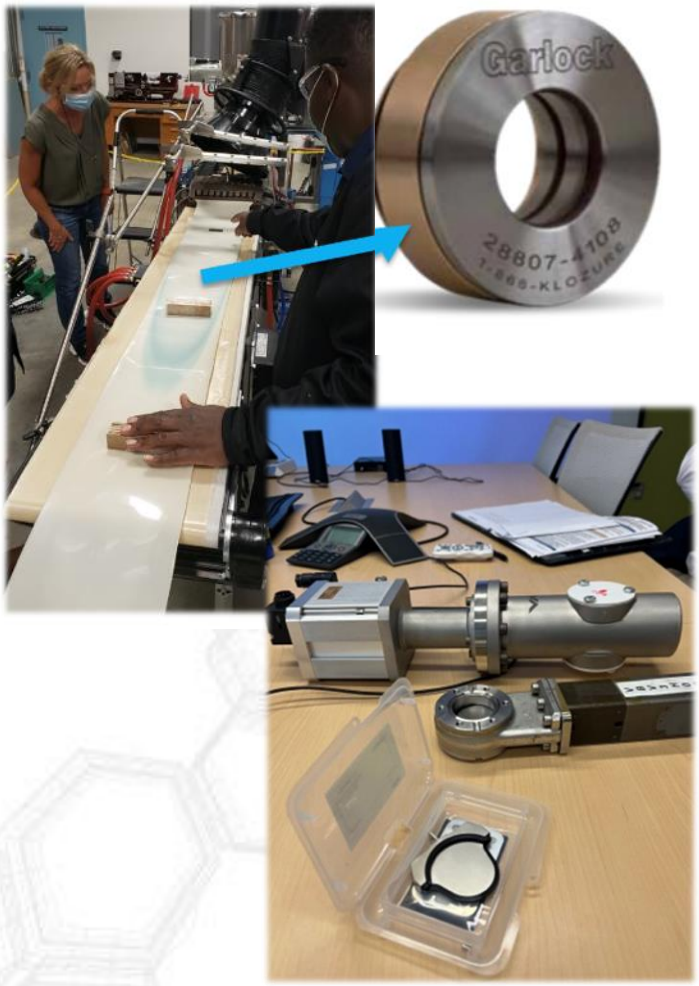
Partners:

- **Jefferson Lab**
- **BNL NSRL and VPT Rad**
- **Virginia Tech**
- **Giles County**

Need Tough Radiation Tolerant Seals for Cryomodule Gate Valves in Jefferson Laboratory's Continuous Electron Beam Accelerator Facility (CEBAF)

NanoSonic's RadSeal™ Solution

Grant #: DE-SC0022482



RadSeal *Flexible Design Space*

- PFAS-free radiation durable materials
- Additively manufactured for specialty designs
- Backed by sales, patents, and trade secrets

- ***Successful demo with Partners***:
  - Qualitative high rad survivability
  - Increase toughness, 40% higher temp

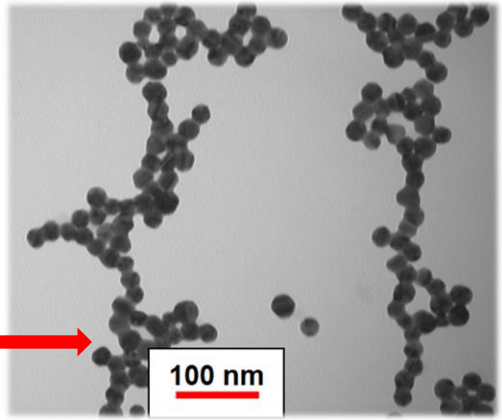
- ***Next steps***:
  - Quantitative 1 – 2 MGy radiation validation
  - Accelerator integrated demo

Jefferson Lab

PFAS-free radiation durable materials additively manufactured at NanoSonic
Monetized for multiple sealing and coating products through DOE vP3

ISO 9001:2015 Certified by NSF-ISR

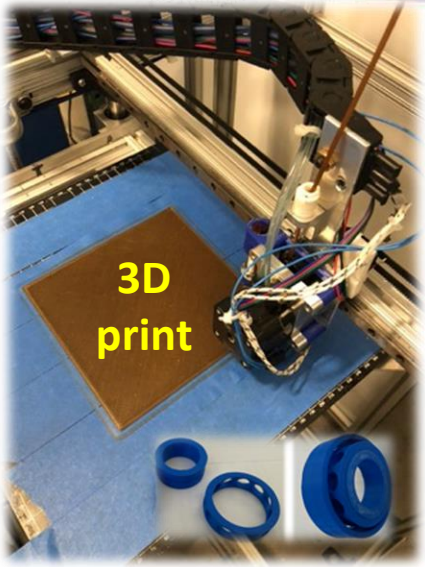
250-gal, 55-gal, 1-10 L in hood, two 20L, and one 100 L reactor

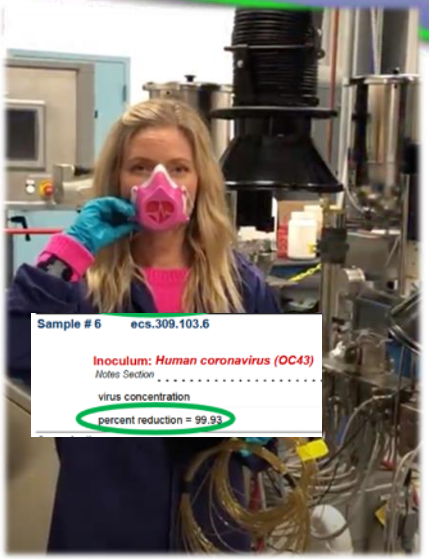


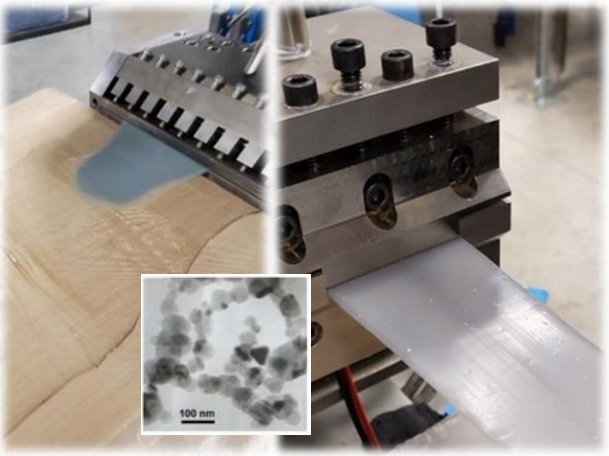
Au from 100 -L

NanoSonic Production Capabilities:

Extrusion and 3D Printing of Radiation Tolerant Polymers, Metals, & Ceramics







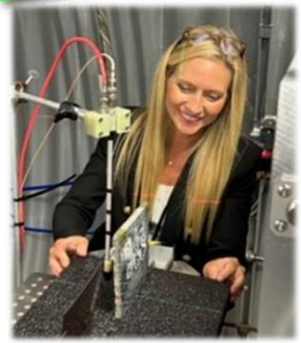
NanoSonic

Team:

NanoSonic, Inc. nanotechnology at work

Brookhaven National Laboratory

Jefferson Lab



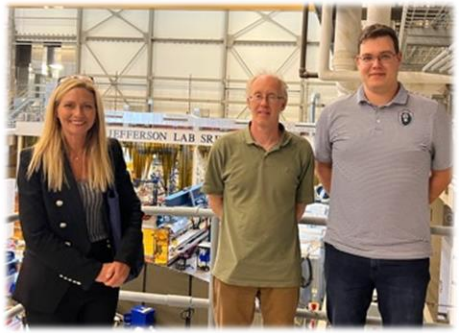
Dr. Jennifer Lalli
President

Courtnay Brand
ISO Lead

Dr. William Harrison
VP Polymer Science

Dr. Brad Gibbons
Chemist

Ben Woods
Industrial Marketing



Dr. Adam Duzik
Dr. David Savransky
Dr. Roger Ruber
JLab

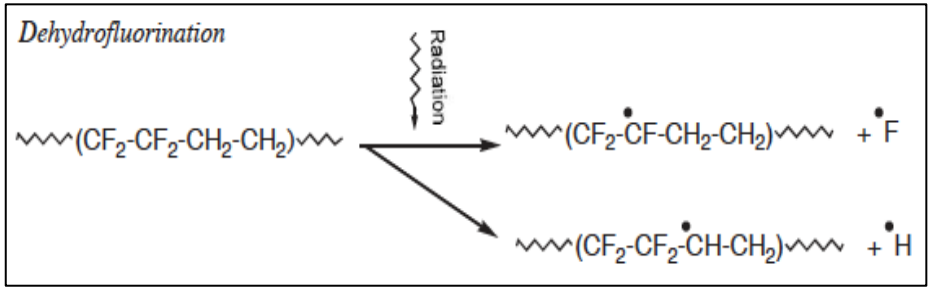
- > 80 years combined Ph.D Chemistry Experience
- ISO 9001:2015
- Commercialized >15 SBIR products
  - www.nanosonic.com
- 2 R&D 100 Awards:
  - HybridSil®
  - Metal Rubber™ patent
- Facility Clearance
  - Shielding Polymers

Dr. Michael Sivertz
BNL NSRL

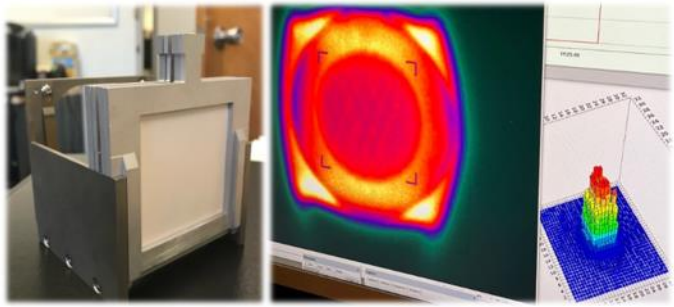
Tough Materials for High Radiation Environments

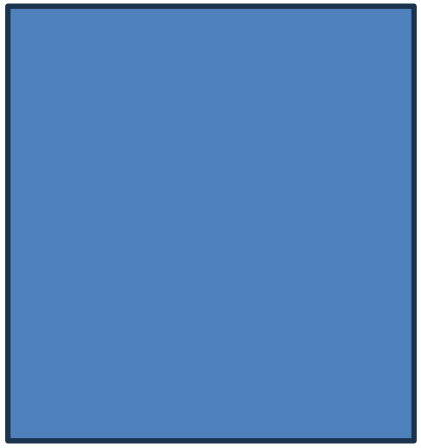
APPROACH:

- Develop new materials with improved radiation toughness over FKM seals



Roadmap to Integration



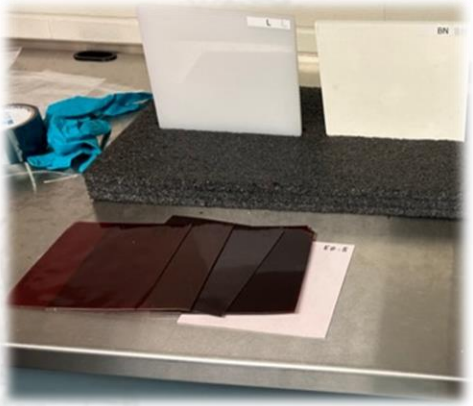


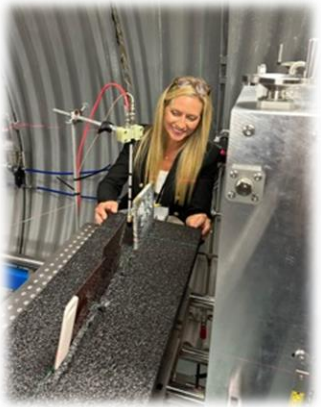
DEVELOP **TEST** **DEMO**

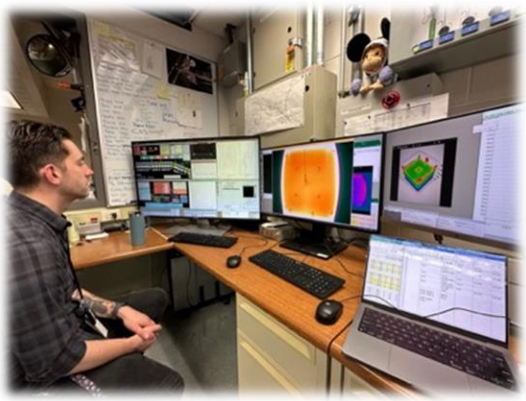
Current Viton Seals Degrade Upon Irradiation and Evolve HF

Technical Approach:

Conduct Radiation Exposure and Durability Studies



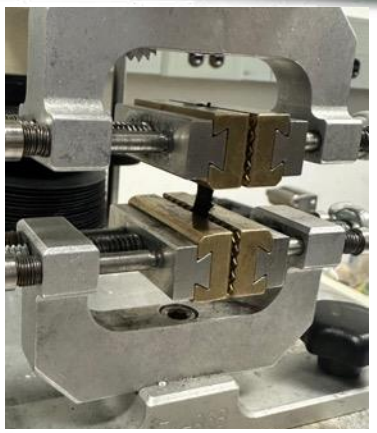


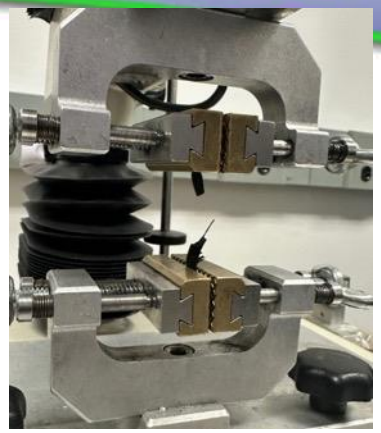


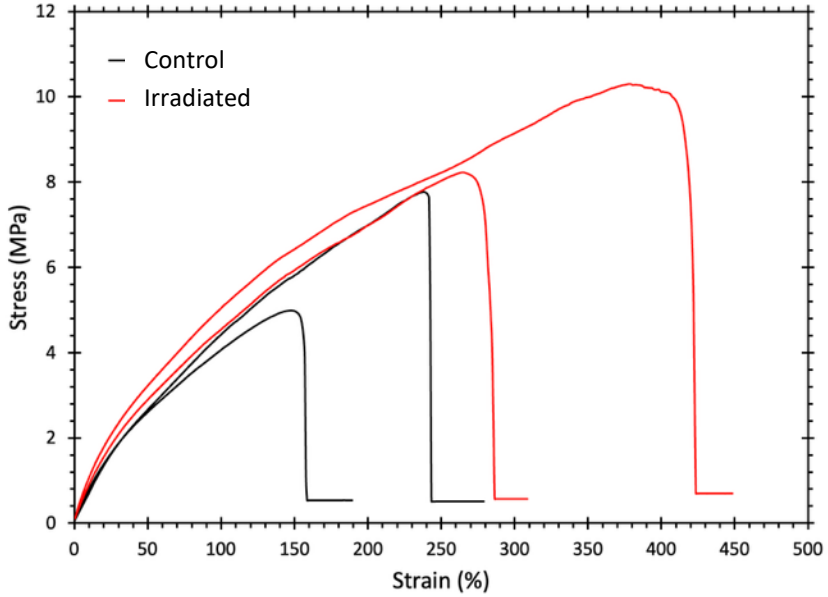
Utilize Scalable Additive Manufacturing Techniques to Develop Materials for Bench Testing Alongside Standards at BNL NSRL

Technical Approach:

Test Mechanical Properties of New Irradiated Materials Alongside Standard

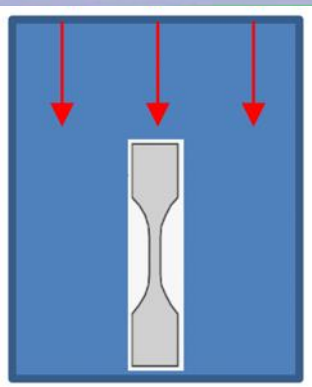
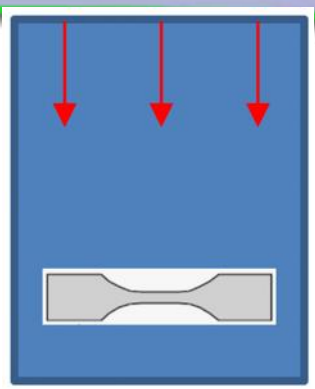
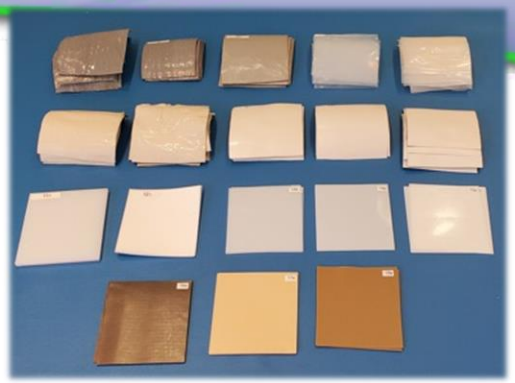




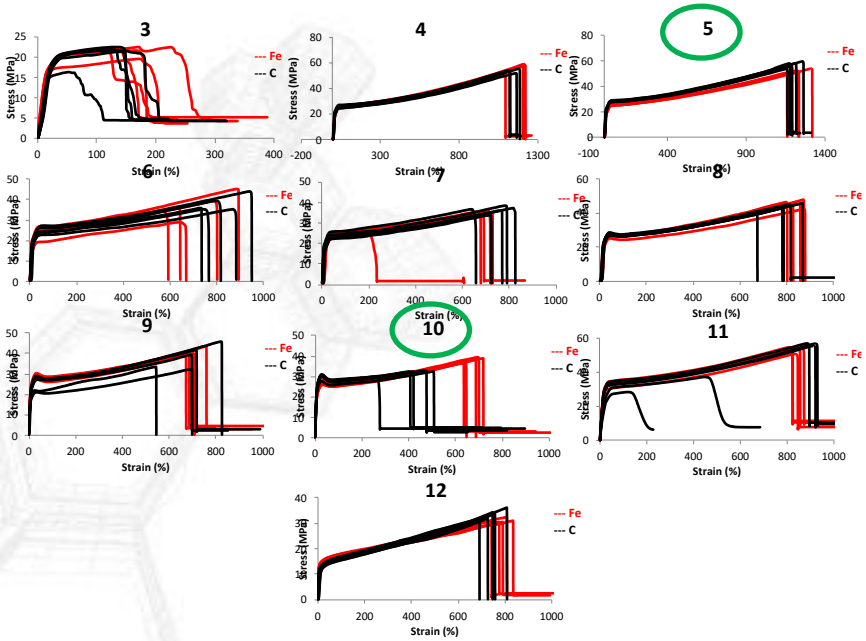


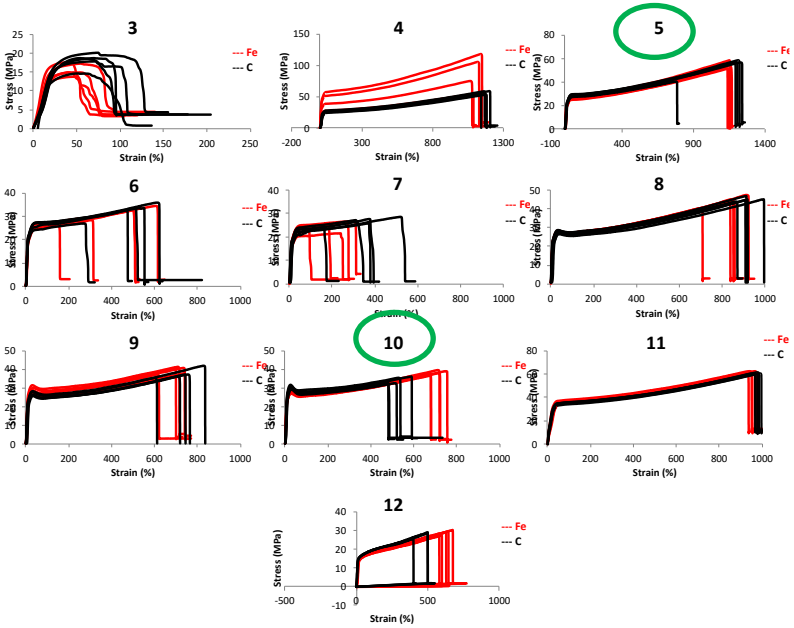
Radiation Exposure of Materials at 1 GeV proton (2 Gy)

Exposure at NSRL to Fe 1 GeV (214 Gy)
Chain Scission vs. Embrittlement

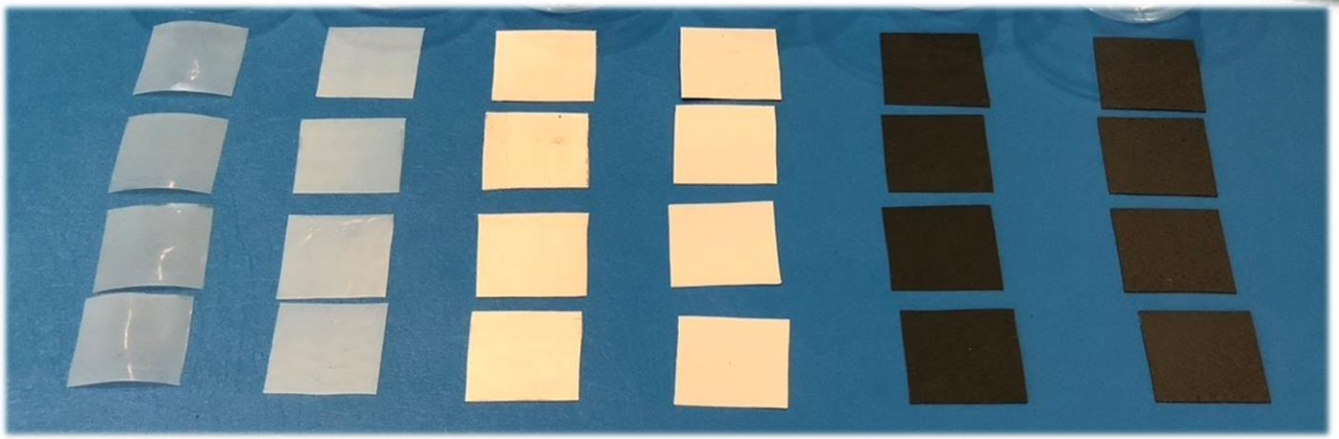
Mechanical Properties for All NanoSonic Films in Parallel and Perpendicular Directions

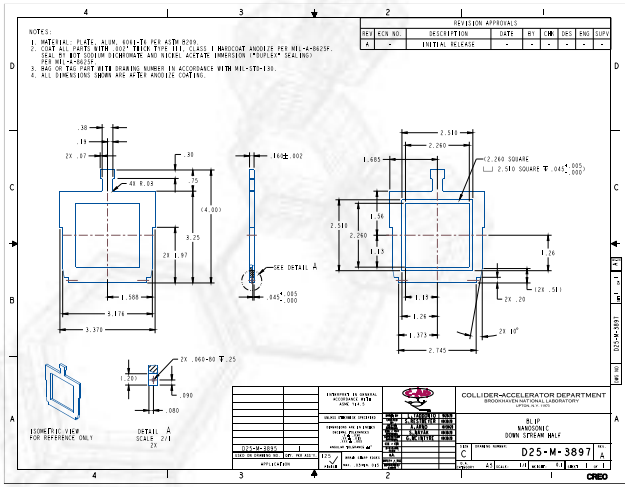


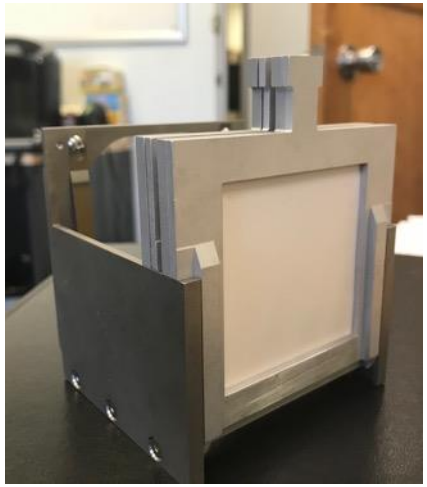


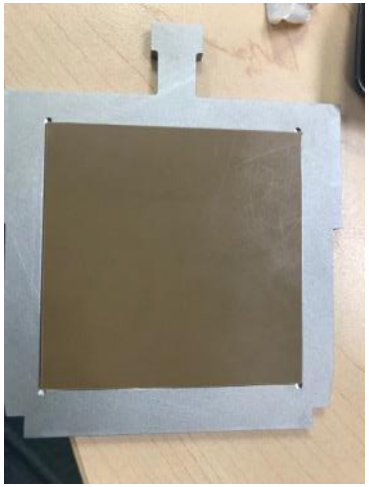
Radiation Exposure 1 GeV Fe (214 Gy)

High Dose Exposure at BNL MIRP (0.2 – 20 MGy)
Delivered Films





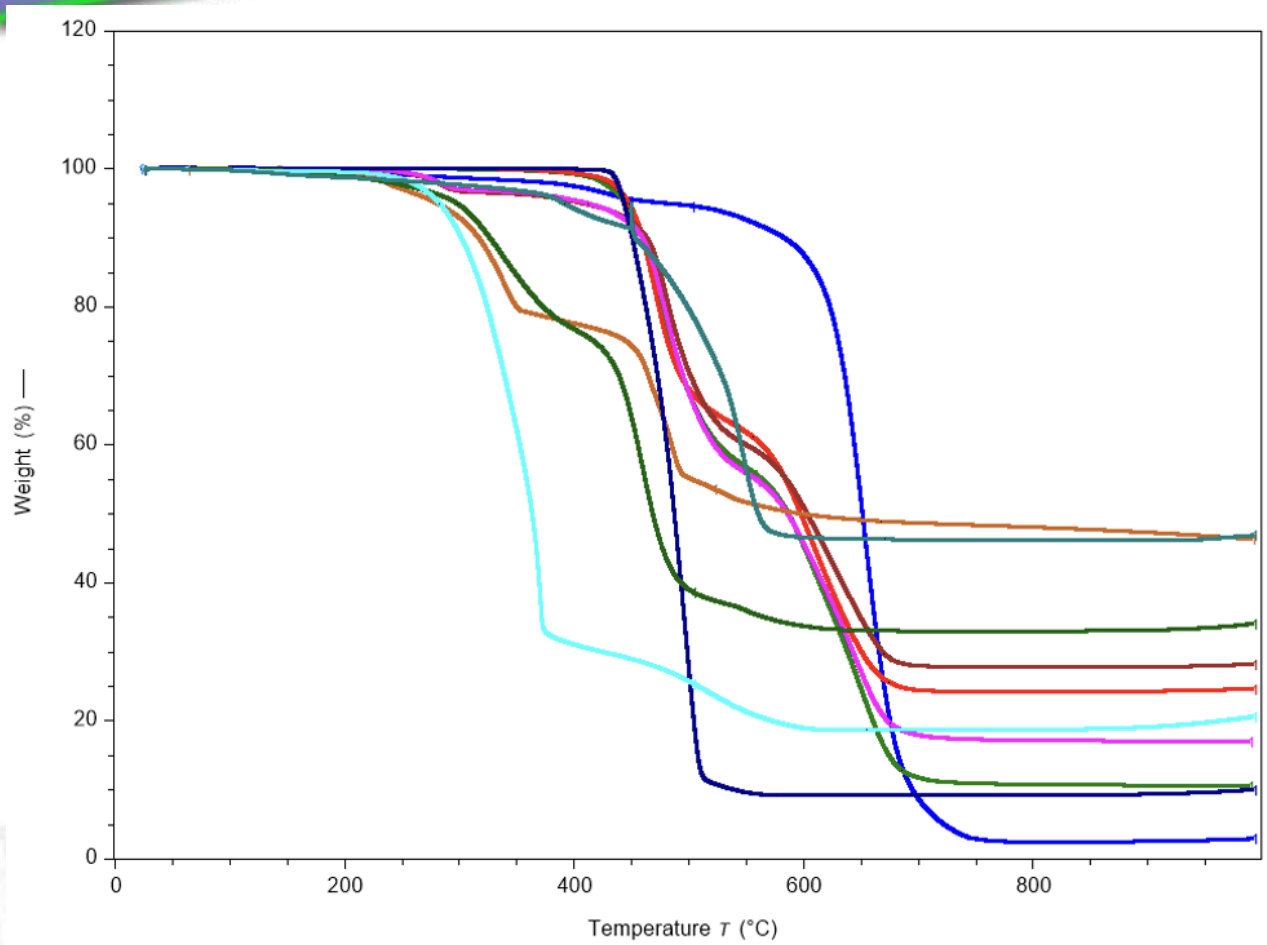


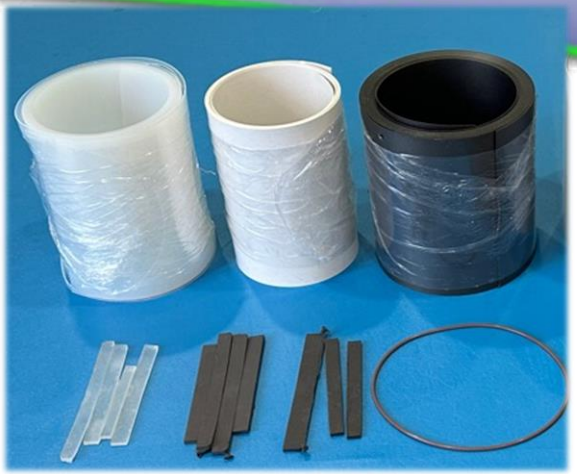


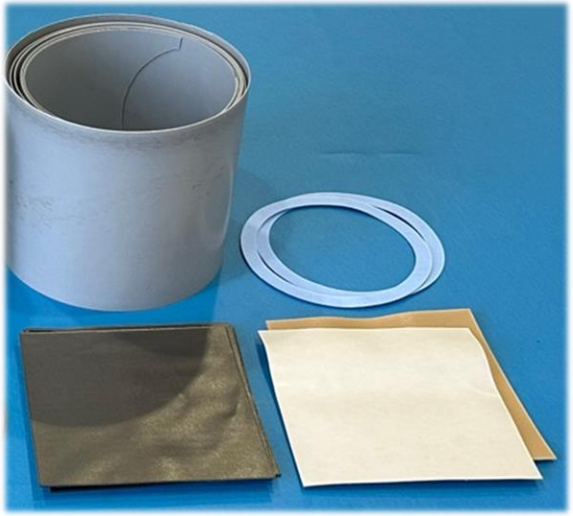
First Run at MIRP ~10.8 MGy – New Run Pending

Technical Approach:

Test Mechanical Properties of New Irradiated Materials Alongside Standard



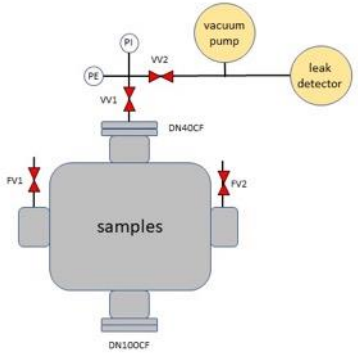


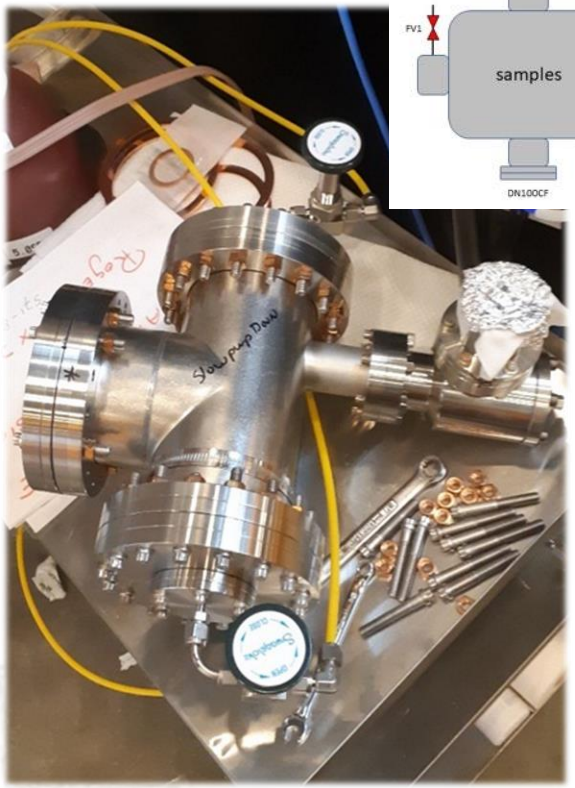


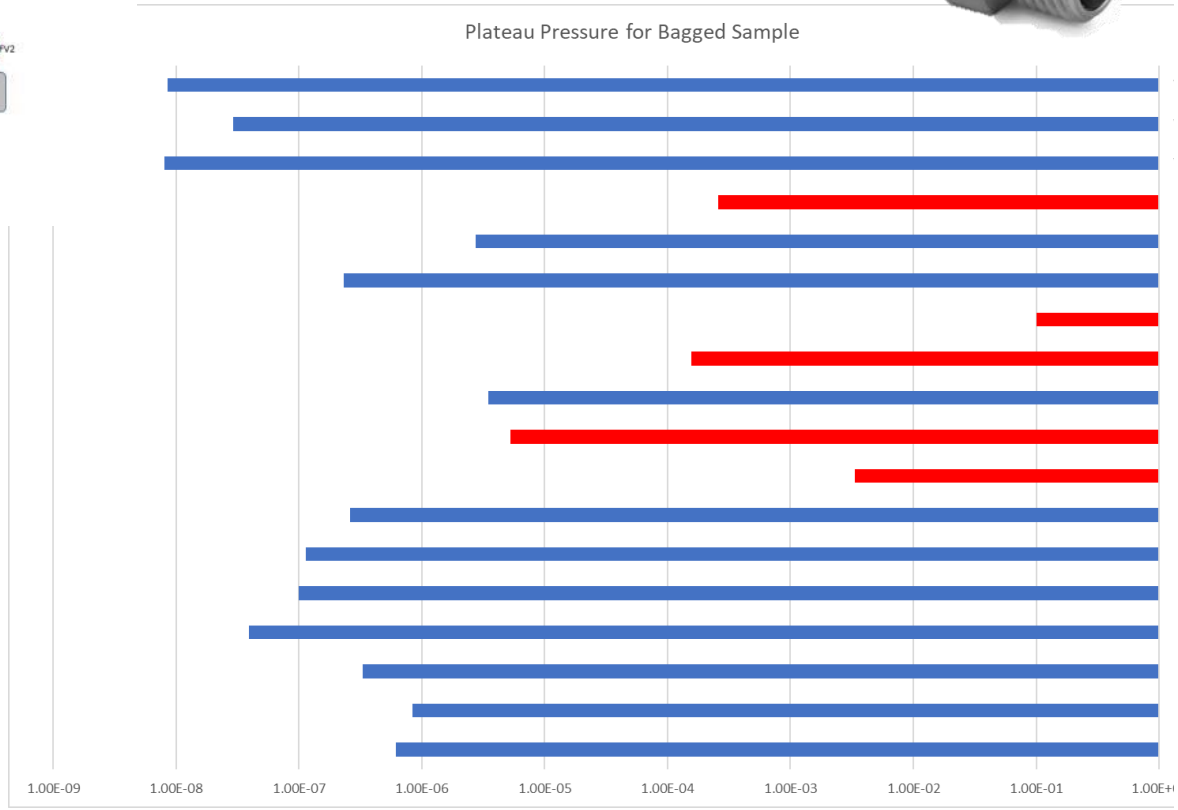
Thermal Stability Characterization via Weight Loss and Char Yield and Down-Selection Prior to Outgassing

Technical Approach:

Test Mechanical Properties of New Irradiated Materials Alongside Standard





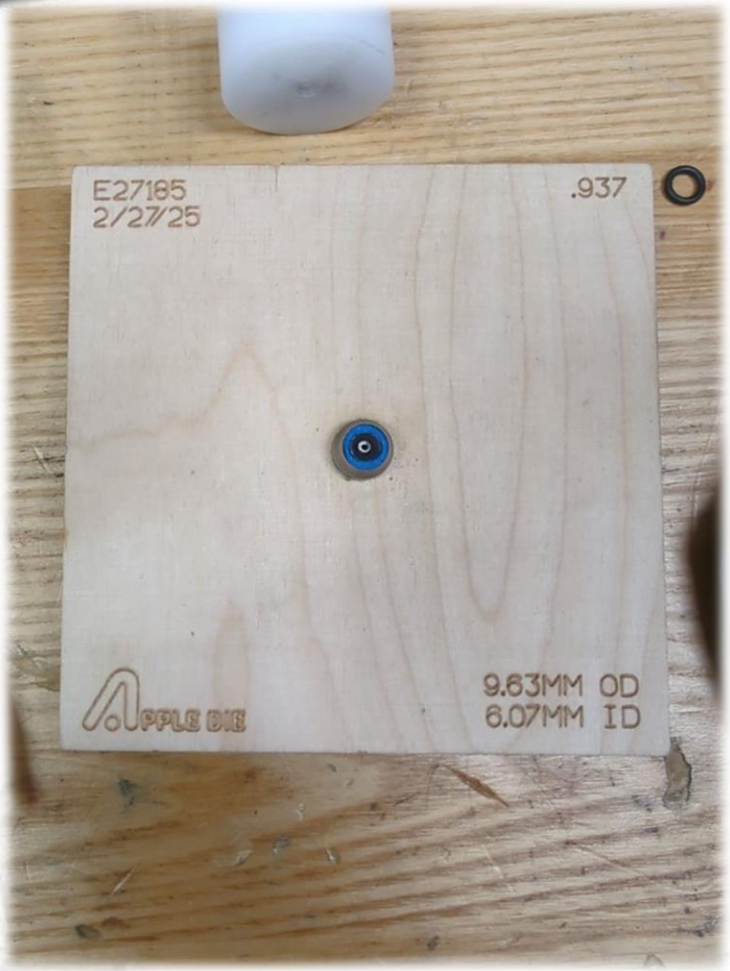


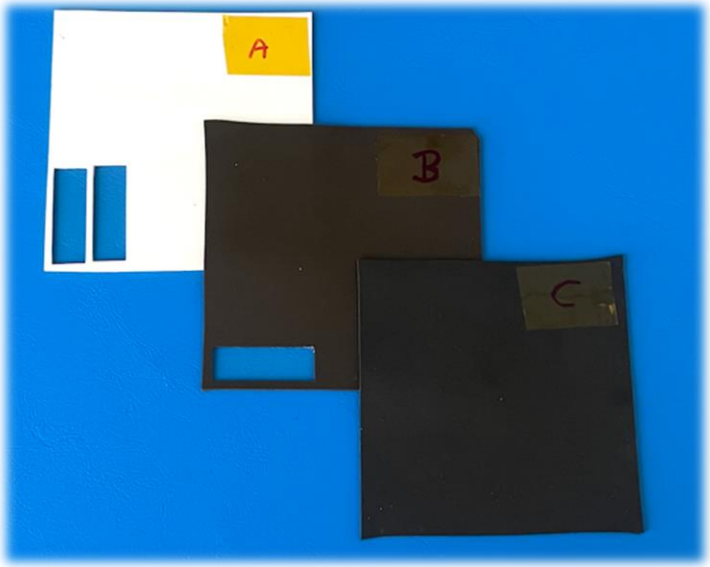
Materials Delivered to Jefferson Lab for Out-gassing

Current Status of Seal

Materials Undergoing Extensive Seal Performance Testing and Down-Selection for High Dose Radiation Exposure at JLab

New punchout die

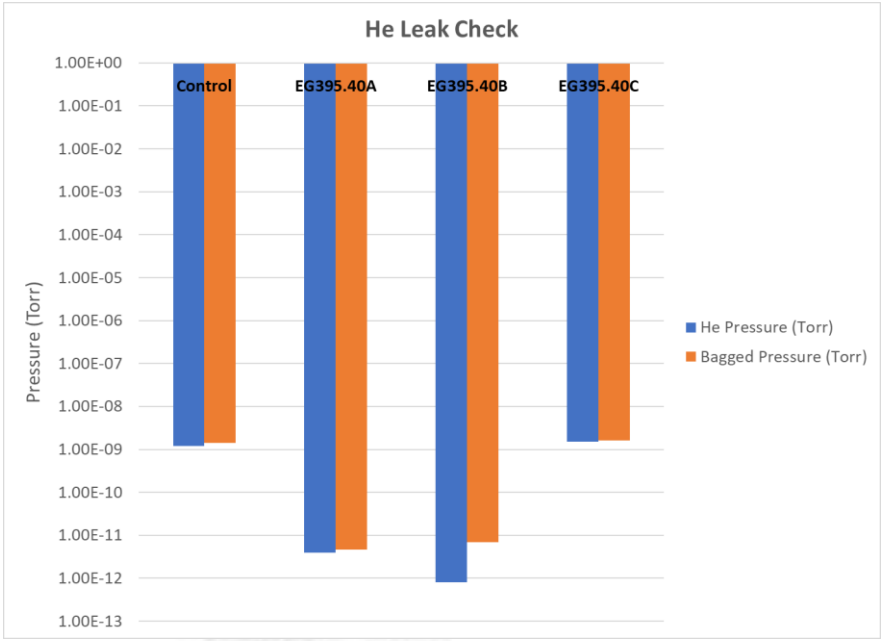




- Tested new control o-ring

Made EG395.40A, B, C test o-rings with new punch

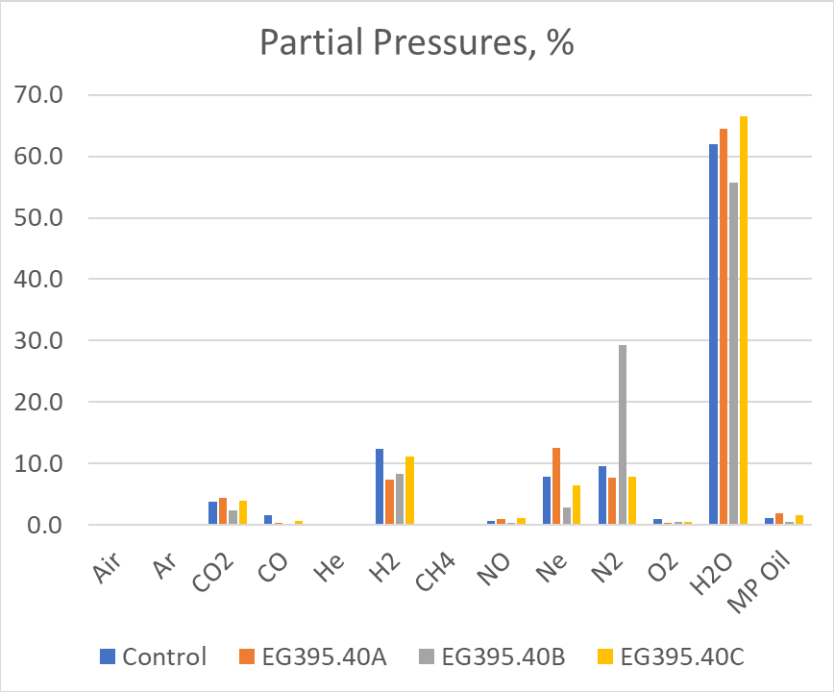
Sample 4 (EG395.40 A-C)

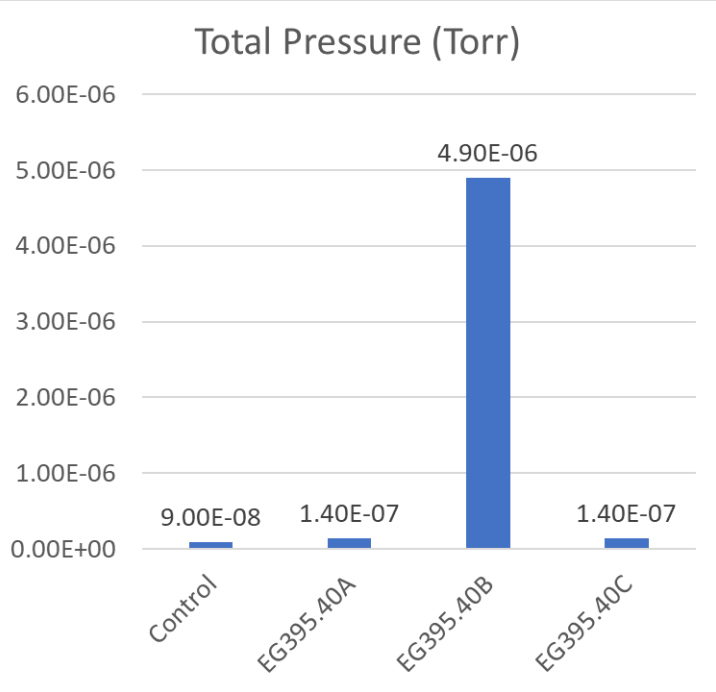


- Did new control o-ring test
- Longer bars = lower pressure, higher vacuum (log scale)
- A and B were best vs. control
- Done with SRS Residual Gas Analyzer (RGA) not Inficon like in past (waiting on software install to get more comparable results)

He Leak Check

Sample 4 (EG395.40A-C)

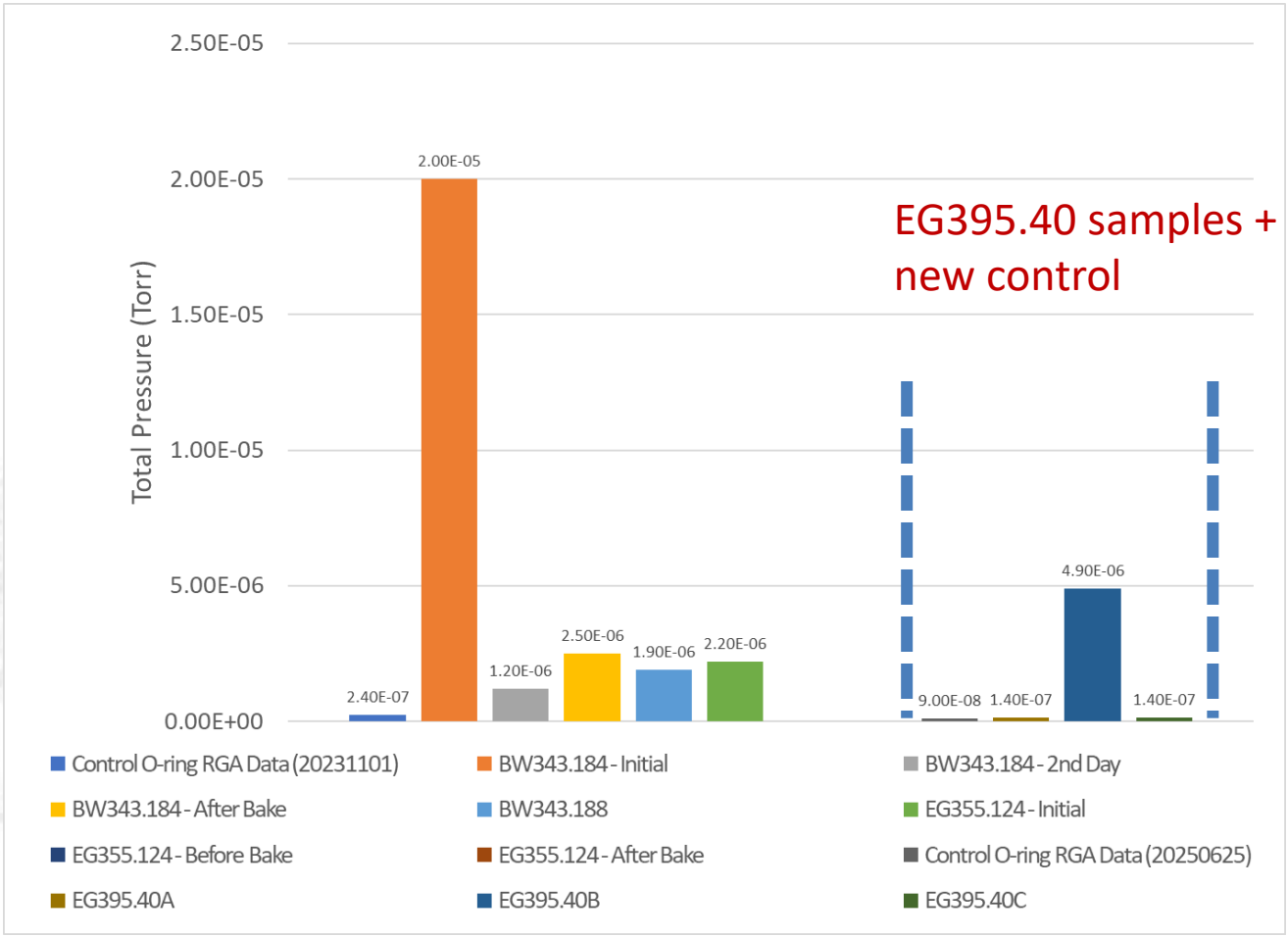




- First samples made with new o-ring punchout die
- High relative water content, but comparable to control
- High outgassing in B, has 50x worse total pressure

Outgassing

Cumulative – Total Pressures

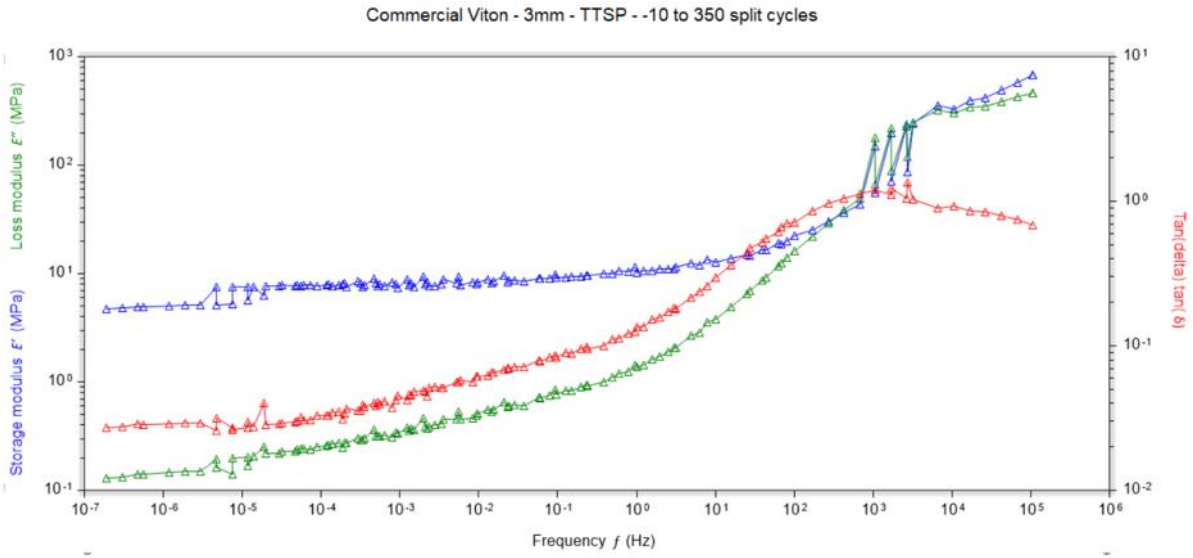


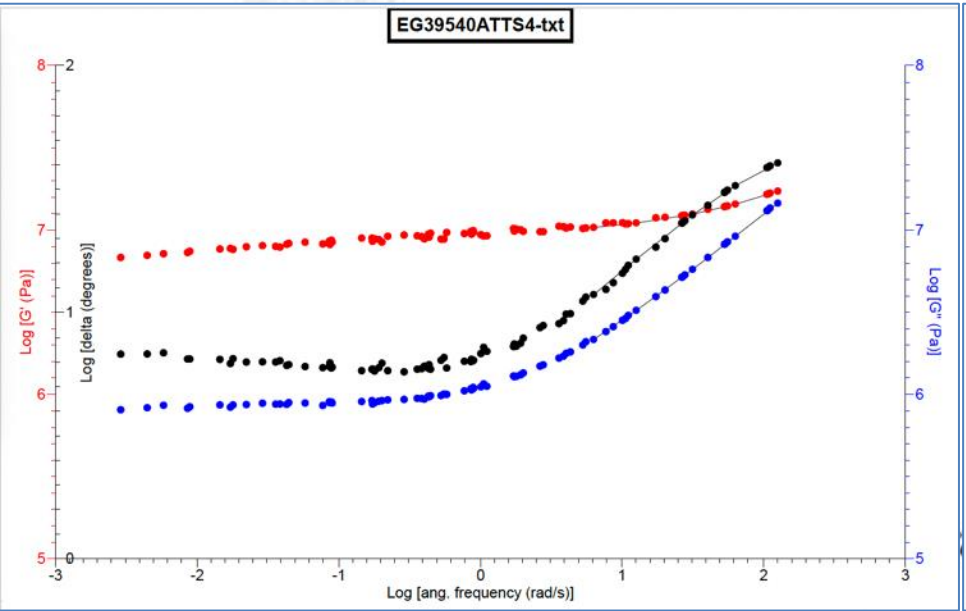
EG395.40 samples outgassing less than previous samples

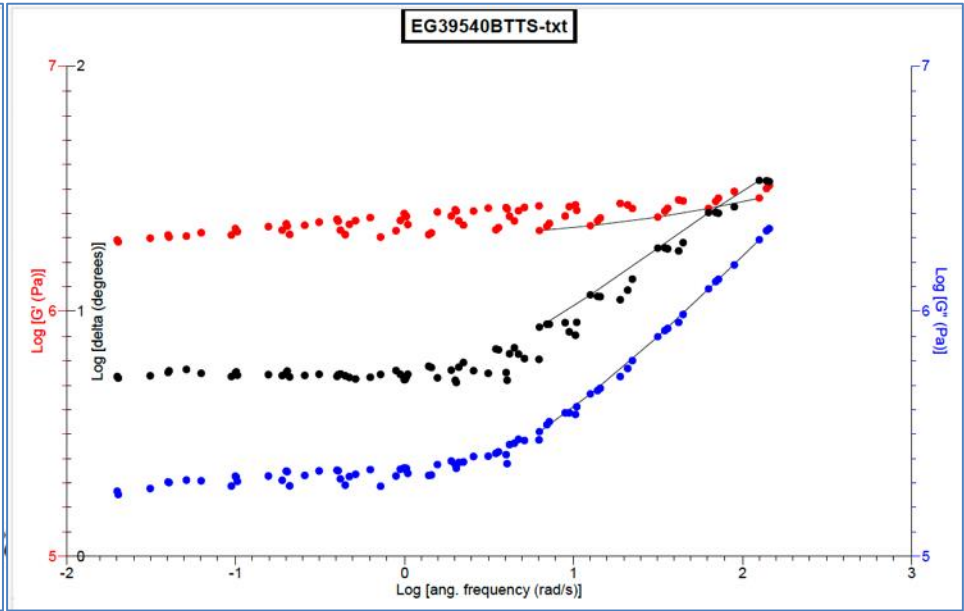
Conclusions

- EG395.40A, B samples have good leak tightness vs. control
- EG395.40A, C exhibit lower outgassing vs. control
- A sample best performance this round
- Only have 1x test for each material – can run more for reproducibility

DMA Lifetime Testing against Viton
-10 °C to 350 °C



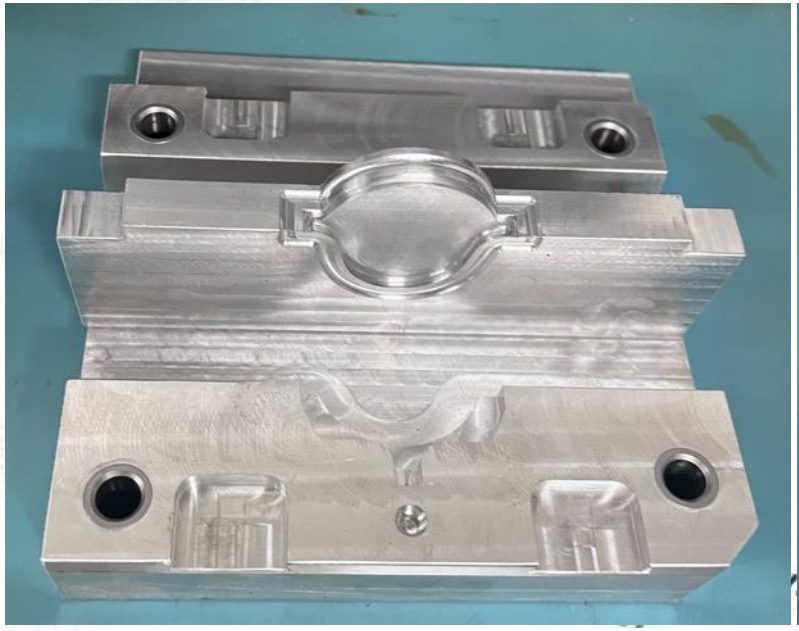
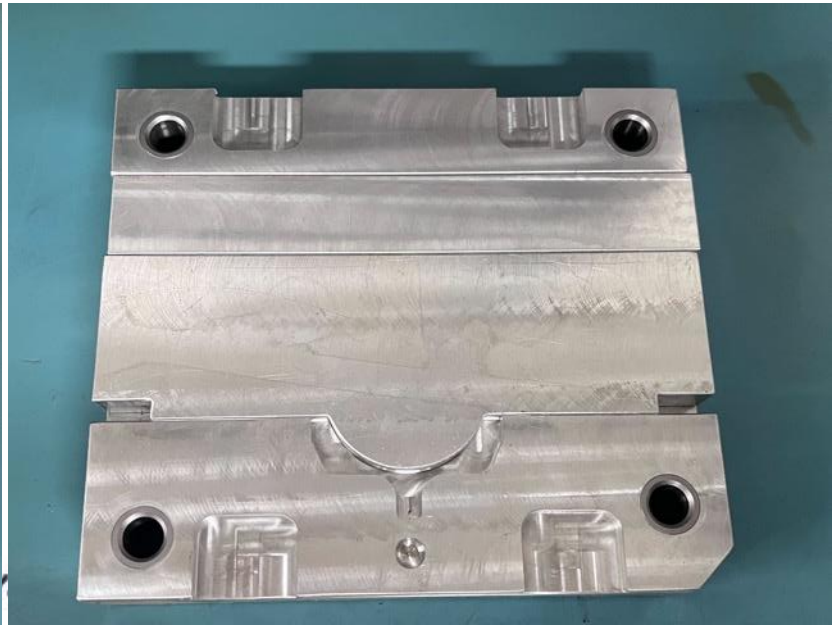




Manufacturing





Go-to Market Traction

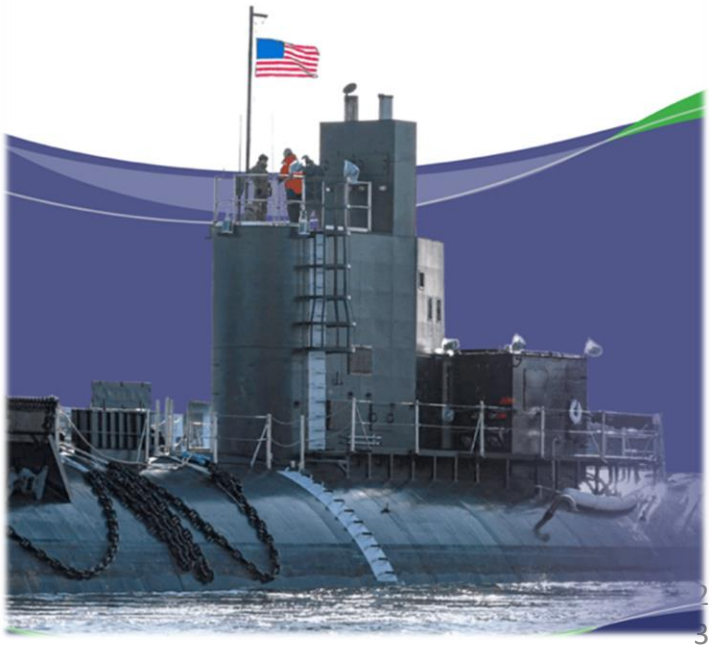
Growth Stage Company

- **Current Customers:**
  - UAV Manufacturers
  - H2 Dispensing
  - Seal Companies
  - Government Laboratories

- **NanoSonic, Inc R&D:**
  - In the black since 1998

- **PRODUCT SALES (non-SBIR)**
  - $250 – 500k avg sales
  - >$2M product sales 24-25

NAVAL NUCLEAR LABORATORY



NanoSonic

Acknowledgements

Dr. Michelle Shinn
Dr. Elizabeth Bartosz, Brenda May, John Motz, Bart Malewski, Kevin J. Kresl, Dr. Manouchehr Farkhondeh, Dr. Carol Rabke, and Dr. Manny Oliver

Drs. Roger Ruber, David Savransky, and Adam Duzik
Jefferson Laboratory

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NanoSonic, Inc.
nanotechnology at work