Low-Z Thin Film Stripper Foils, Targets and X-Ray Windows

Contract # DE-SC0011287

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Outline

- Overview of UHV Technologies/nanoRANCH
  - History and Core Competencies
- DOE NP Phase II SBIR Project
  - Free Standing Multi-Layer Diamond Stripper Foils
  - Diamond X-Ray Windows for Low Energy Detectors

UHV Technologies, Inc. (aka nanoRANCH)

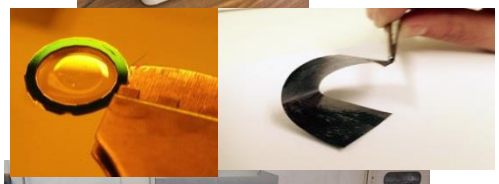
- **25 year old high tech company with facilities in Lexington, KY and Fort Worth, TX**
  1. **New headquarters in Lexington, KY opened in 2016**
  2. **Over 20,000 sq. ft. combined Manu. & R&D Space**
  3. **Active collaboration with 10+ Universities**
- **3-Prong business strategy**
  1. **R&D in Advanced Thin Films, Diamond, Nano-Materials & Devices, X-Rays, Artificial Intelligence and Deep Learning, & Optical Fiber Coatings**
  2. **In-House Small Scale Manufacturing**
  3. **Commercialization through Subsidiaries and Alliances**
  4. **Various spin-offs including 1 IPO (NASDAQ) and > 22 million in Venture Capital**
- **Current Status**
  1. **20+ employees**
  2. **$2.7M revenue in 2017, $3.2M expected in 2018**
  3. **Multiple R&D contracts and products**

R&D Facilities

Current Projects/Products

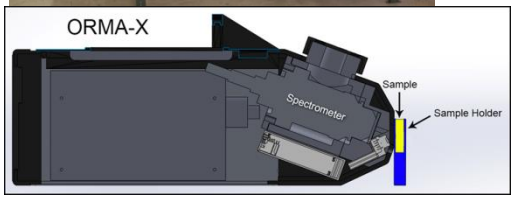
1. **Mercury Air Continuous Emissions XRF Monitor (CEM) 2013-16**
   - US-DOE Phase II Project + Matching funds from KY
   - Spin-off: nanoRanch Environmental Systems, LLC in Lexington, KY

2. **Nano-Crystalline Low-Z Thin Films for X-Ray Windows 2014-17**
   - US-DOE Phase II Project and KY Matching Grant

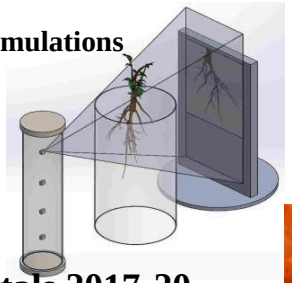


3. **In-Line High Throughput XRF Scrap Metal Sorter 2014-19**
   - Funded by US-DOE ARPA-E Project and Commercial Partners
   - Uses advanced sensors and artificial intelligence; throughput ~ 100M lbs/year
   - Currently supplying large scale industrila equipment to Scrap Processors

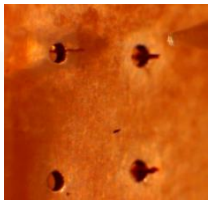
4. **On-Line Real Time Metal Analyzers for Pharma Industry 2015-18**
   - NIH Phase II SBIR Project and KY Matching Grant
   - Real time contamination detection in solid, liquid and gel formulations



5. **Stationary CT for *In-Situ* Imaging of Roots 2017-19**
   - US-DOE ARPA-E Project

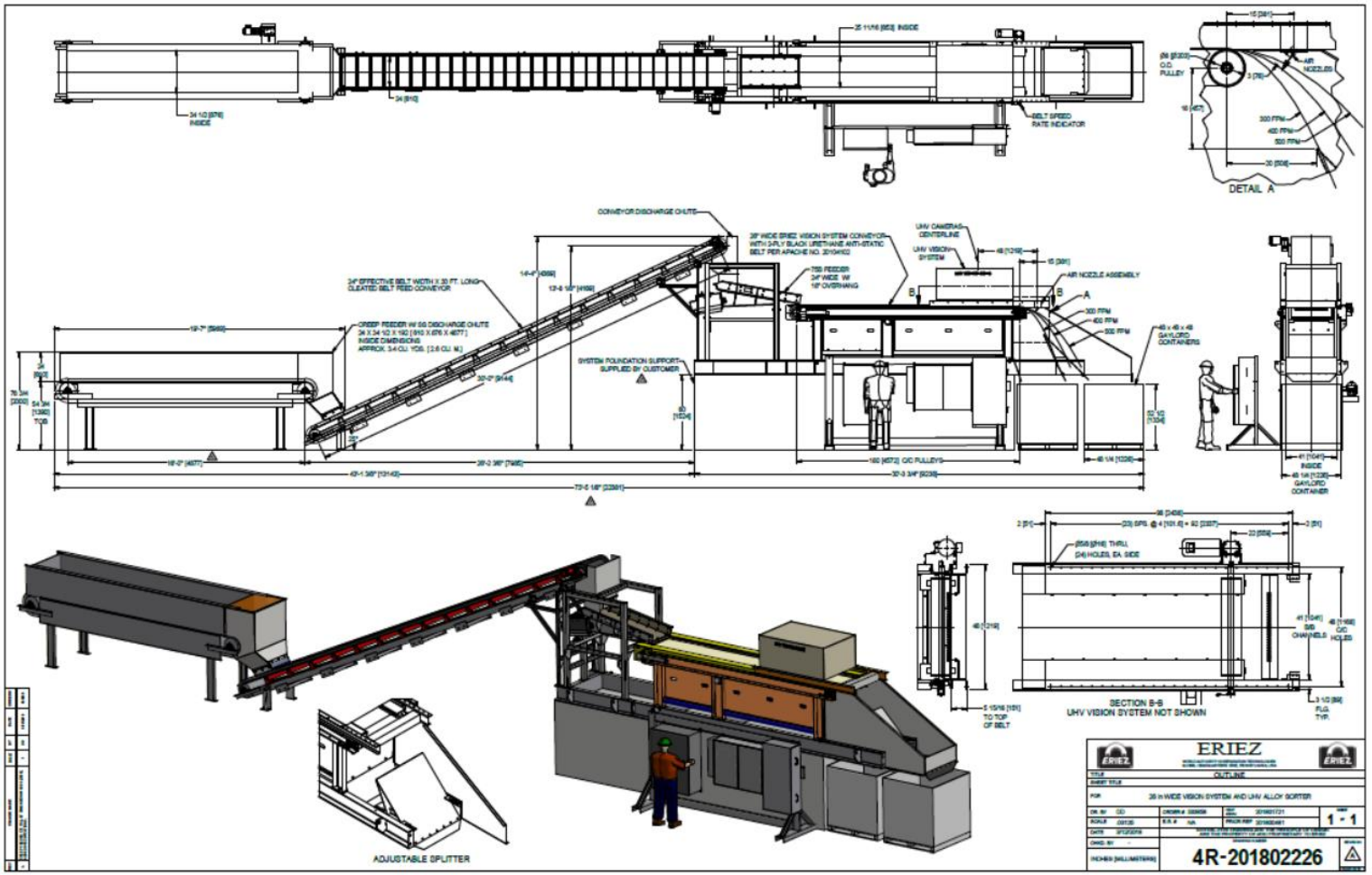


6. **A Scalable Low Temp Additive Manuf. Tech. for Metals 2017-20**
   - US-DOE Phase II SBIR Project: Large Area PCBS for NP Gas Detectors
   - US DOE Phase I SBIR Project: 3D stacked ICs for Radiation Detectors
   - NASA Phase I SBIR Project: In-Space Manufacturing of Metallic Alloys



Product Photos

30 Million LBs/Yr Scrap Sorter

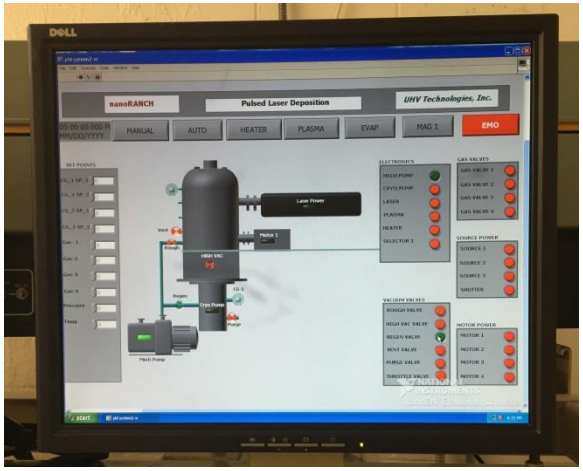


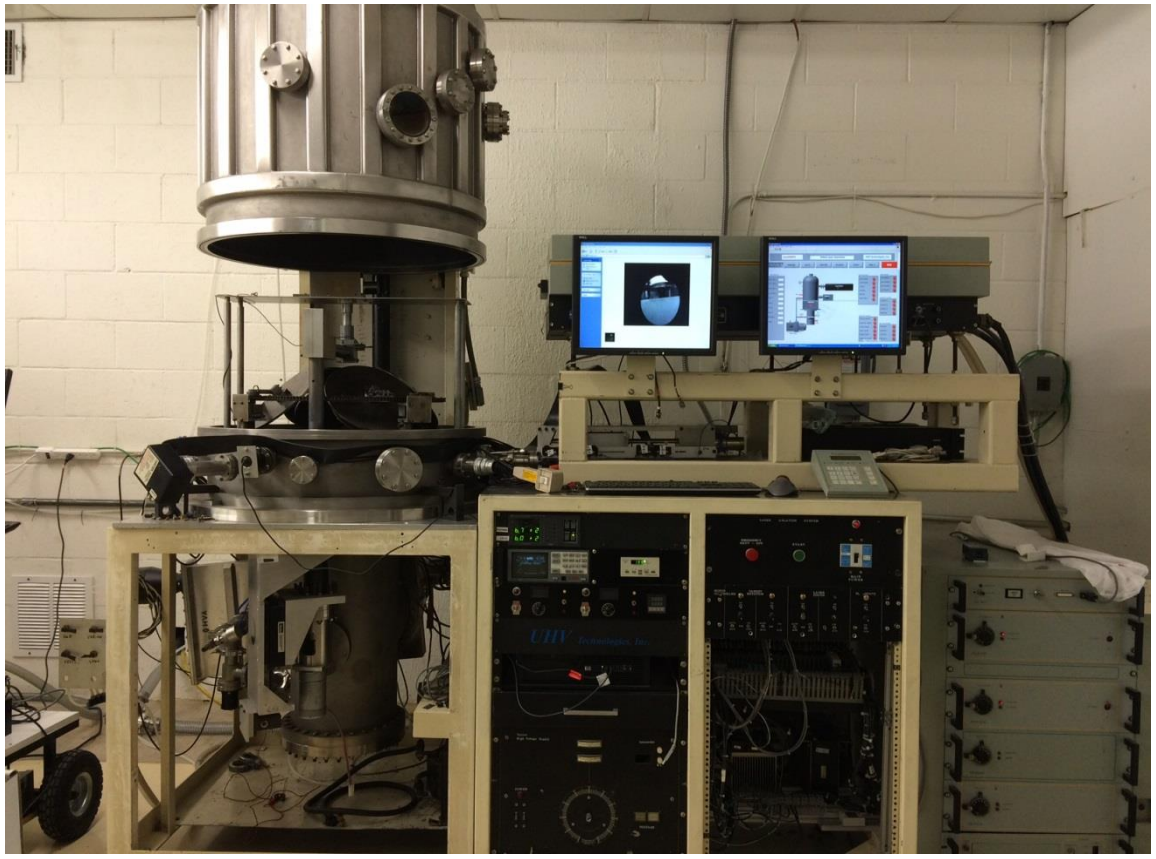
UHV Technologies, Inc.

NP Phase II SBIR
Low-Z Stripper Foils, Targets and Windows

- **Team:** UHV and NSCL/MSU (Dr. Wolfgang Mittig)
- **Objective:** The goal of this project is to develop technologies for the production of **free standing low Z thin films** in the range from a few ug/cm^2 to over 100mg/cm^2 for applications as charge strippers and targets in heavy ion accelerators as well as x-ray windows for low energy x-ray detectors and gas ion detectors.
- **Key Technical Concept**: Free Standing Thin Films consisting of 10-100's of stress controlled nano-layers
- **Enabling Technologies:**
  - Fully automated nano-layer PLD manufacturing system
  - Instrumentation for *in-situ* measurement and control of stress in individual and multi-layer thin films
  - Computer controlled process optimization

Automated Stripper Foil Manufacturing System



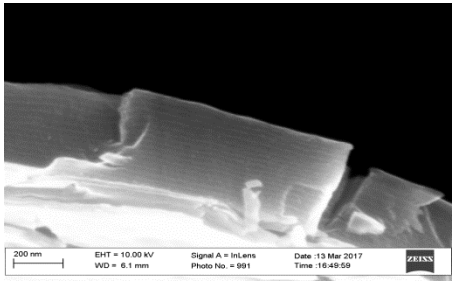


100+ Layer C-B Thin Film Design

PAD nano-Carbon Layer
PLD nano-Diamond Layer
PAD nano-Carbon Layer
PLD nano-Diamond Layer
PAD nano-Carbon Layer
PLD nano-Diamond Layer
PAD nano-Carbon Layer
Release Layer
Substrate

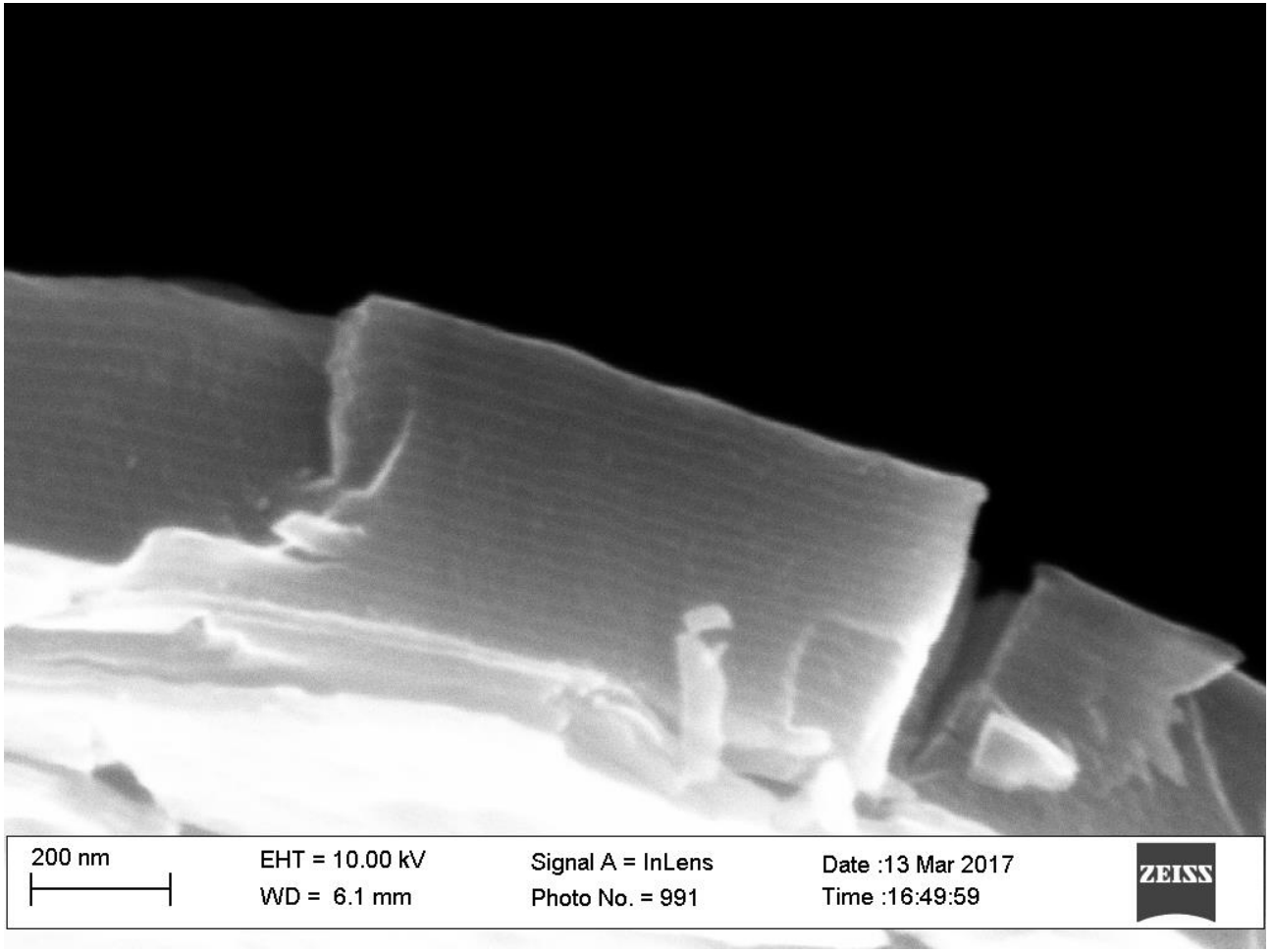
PLD nano -Diamond Layer
PLD nano -Boron Layer
PAD nano -Carbon Layer
PLD nano -Boron Layer
PAD nano -Carbon Layer
PLD nano -Diamond Layer
PAD nano -Diamond Layer
Release Layer
Substrate

PLD nano -Diamond Layer
PLD C-B Mixed Layer
PAD nano -Boron Layer
PLD C-B Mixed Layer
PAD nano -Boron Layer
PLD C-B Mixed Layer
PAD nano -Diamond Layer
Release Layer
Substrate

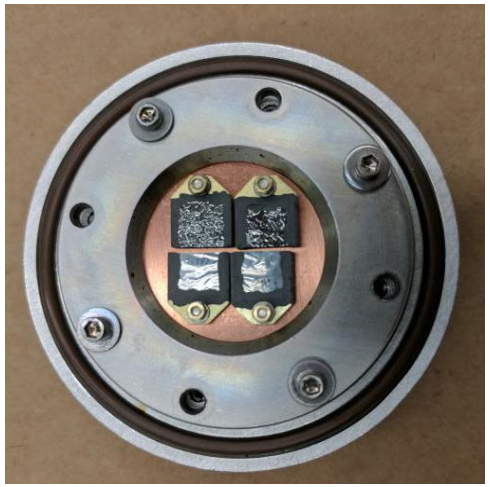


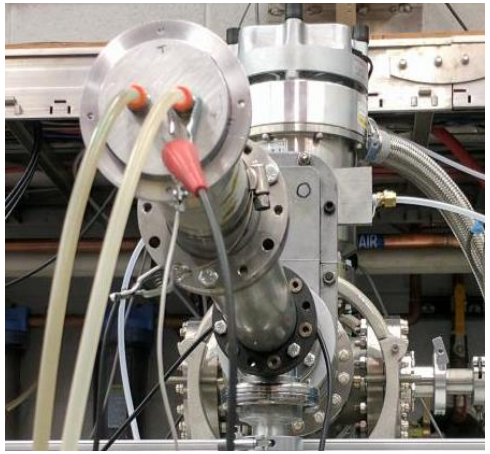
SEM of Multi-Layer Foils

C-B Foil
48 Layers
B/C= 10%



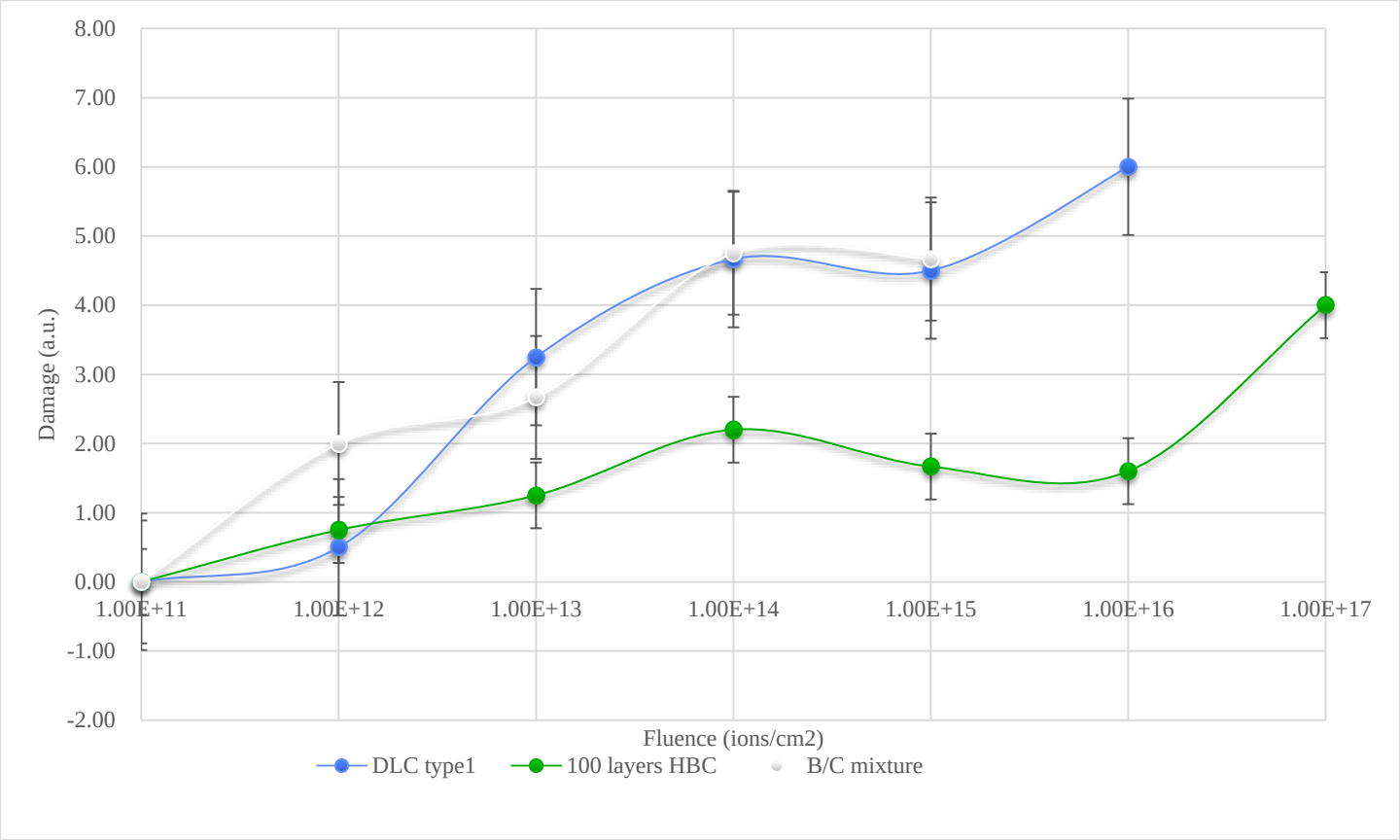
Irradiation Damage to Foils



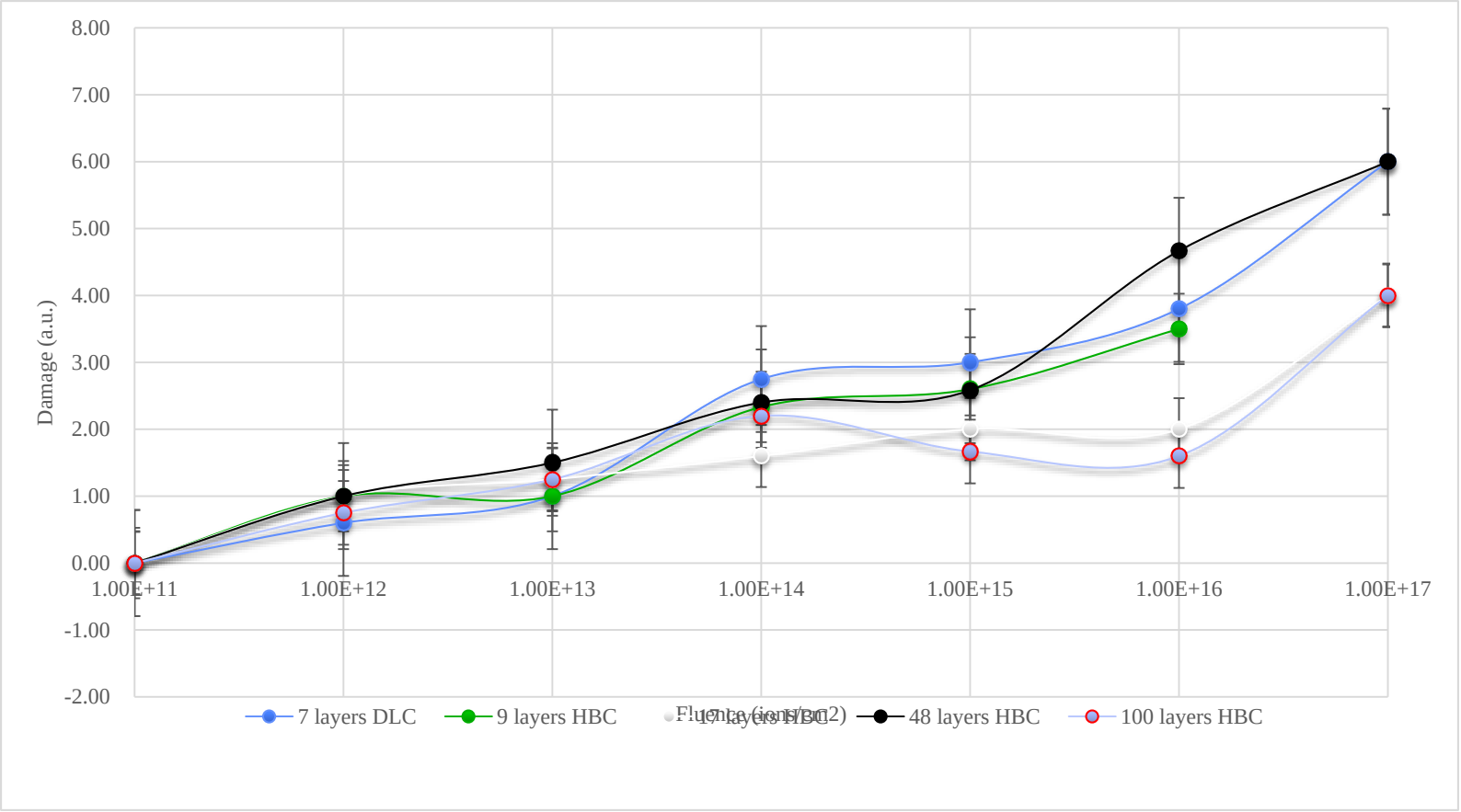


	BEFORE	AFTER
7-Layer HBC		
100-Layer HBC		

Damage for Various Types of Foils



Damage vs Number of Layers



CONCLUSION: 100 layer foils are better than all others foils tested

Low Energy X-Ray Window Development

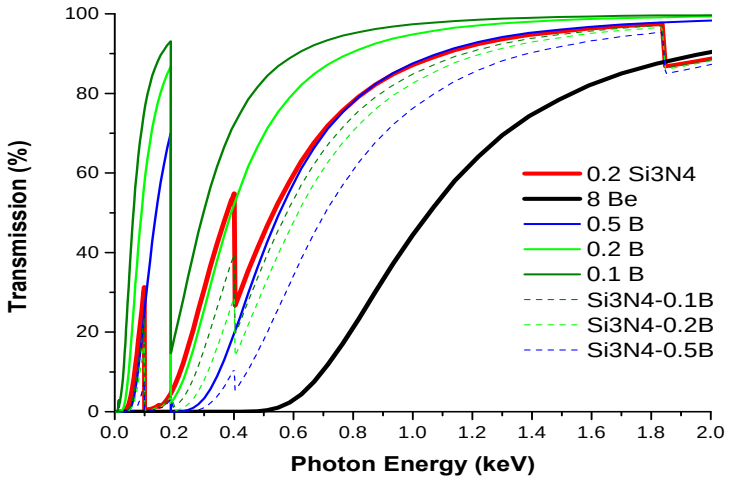


Figure 1: A comparison of low energy low energy x-ray transmission of diamond (C) and boron (B) windows of different thicknesses in comparison with standard Be window.

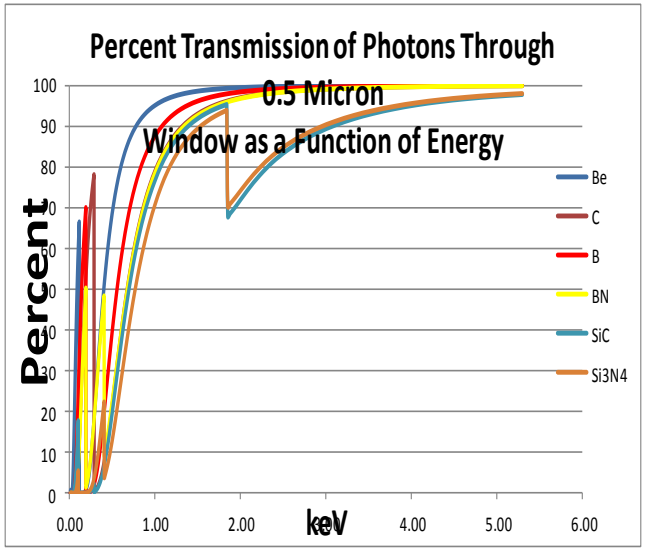


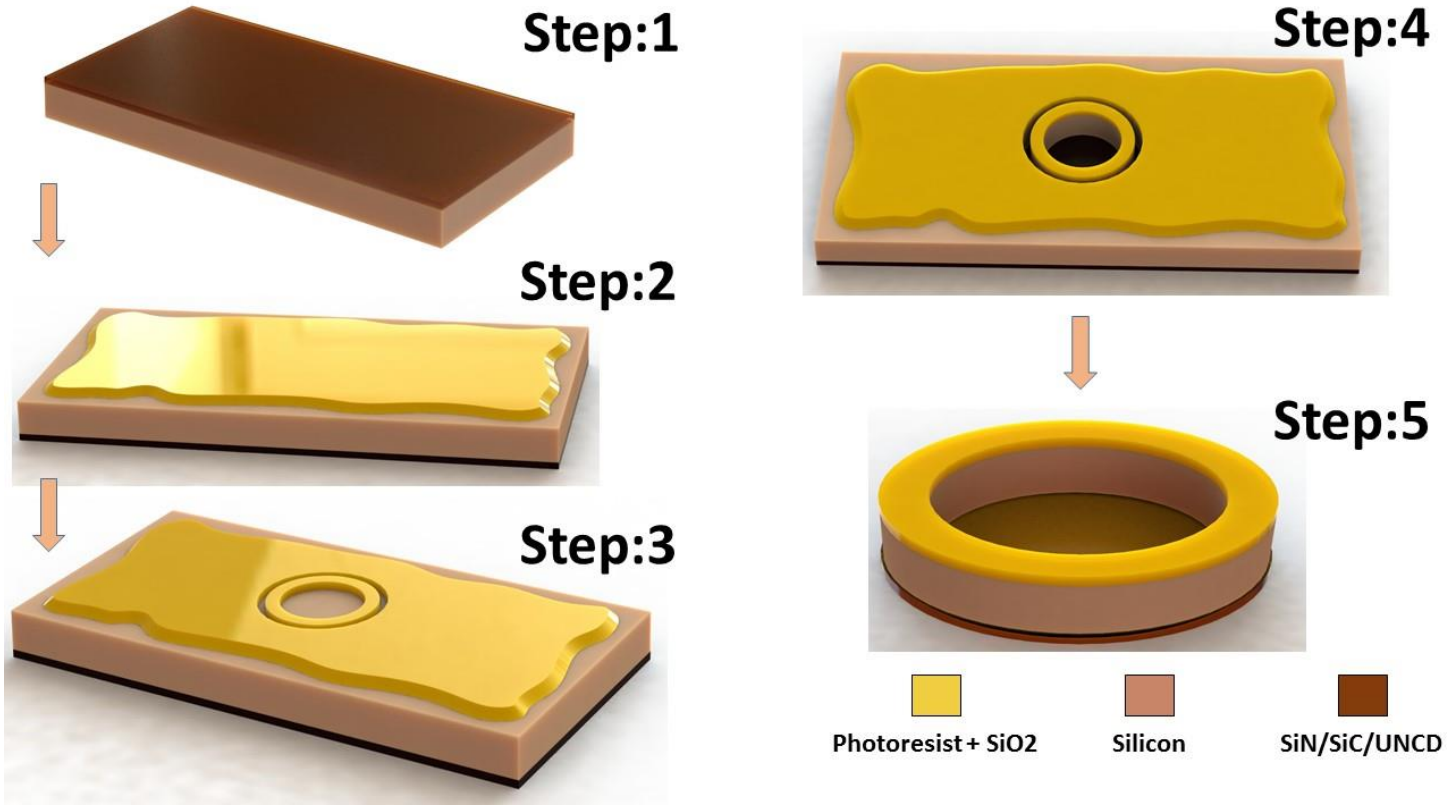
Figure 2: Calculated x-ray transmission curves for 0.5micron thick films of various materials at UHV.

Low Energy Window Design

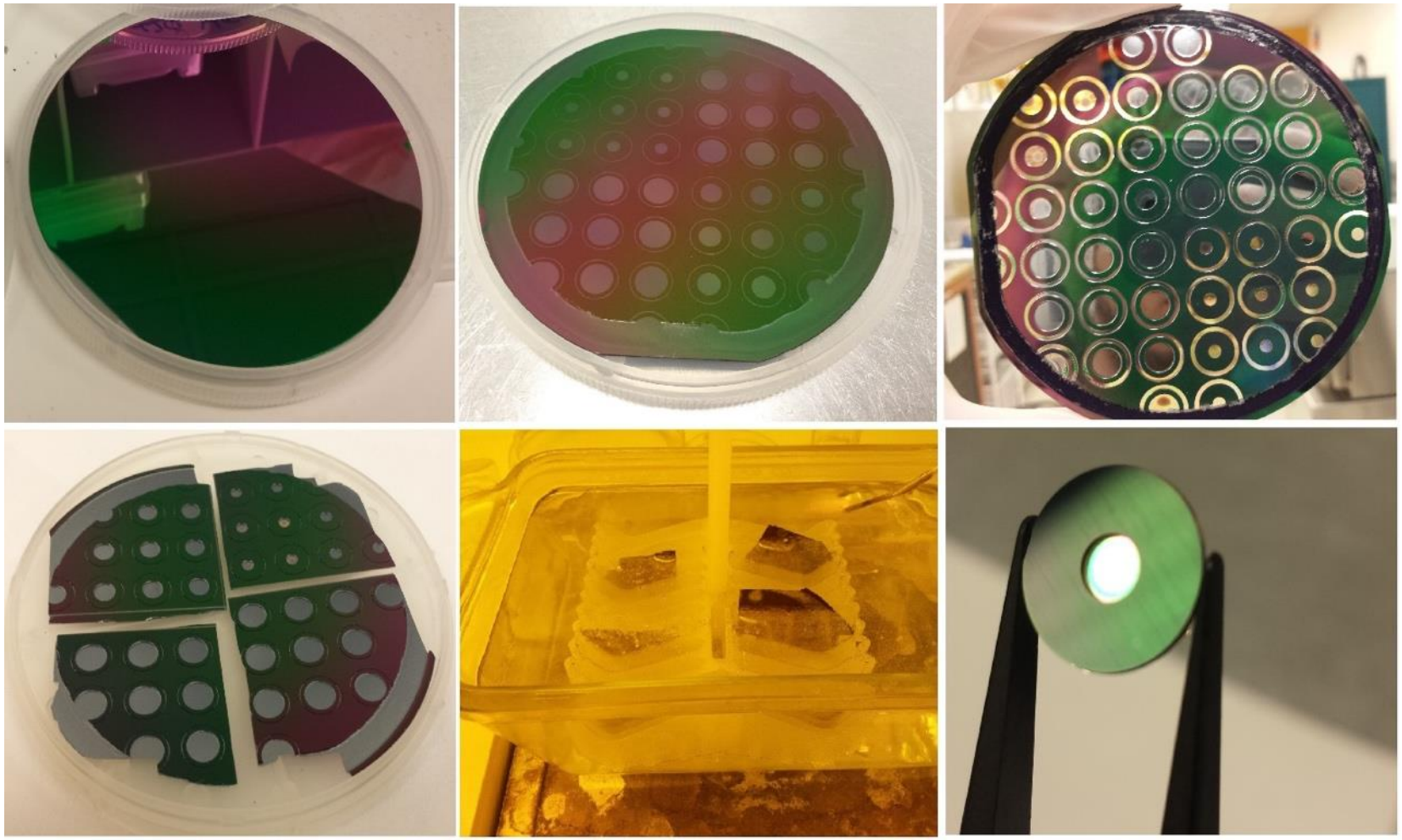
Figure 4: A photograph of a 9mm diameter 200nm thick Si_3N_4 window made by UHV.

Figure 5: Photograph of a sealed x-ray detectors made by Ketek using 9 mm diameter Be window.

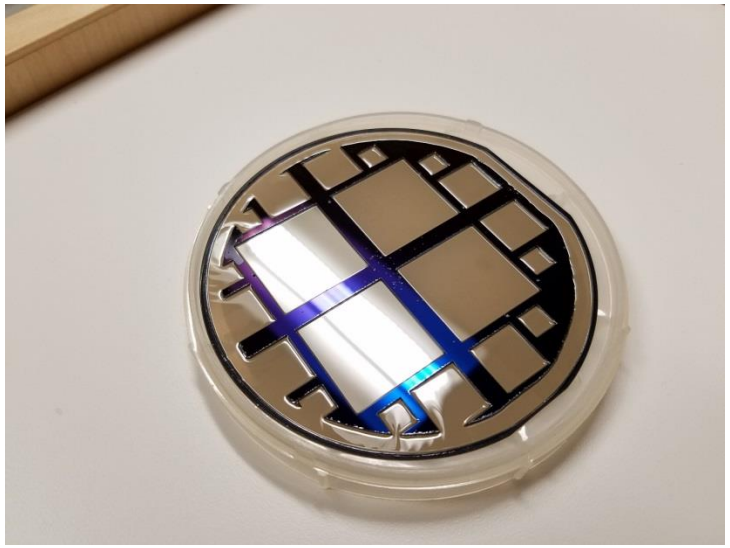
Fabrication Process

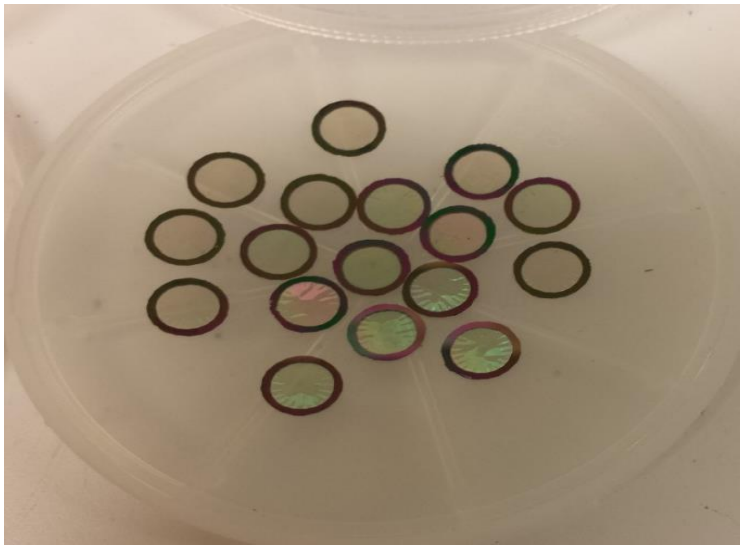


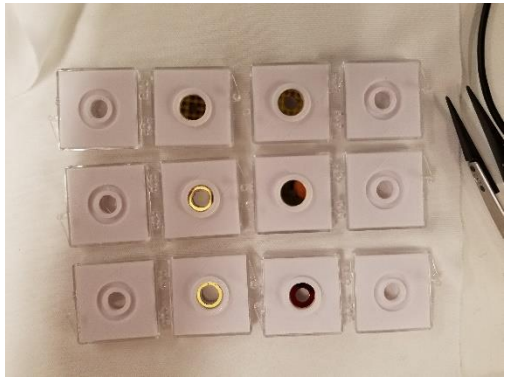
Wafer Fabrication

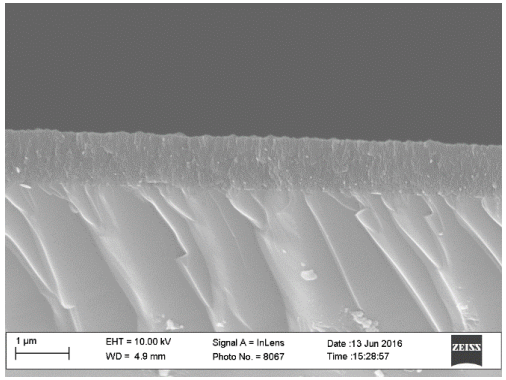


Photographs of Various X-Ray Windows

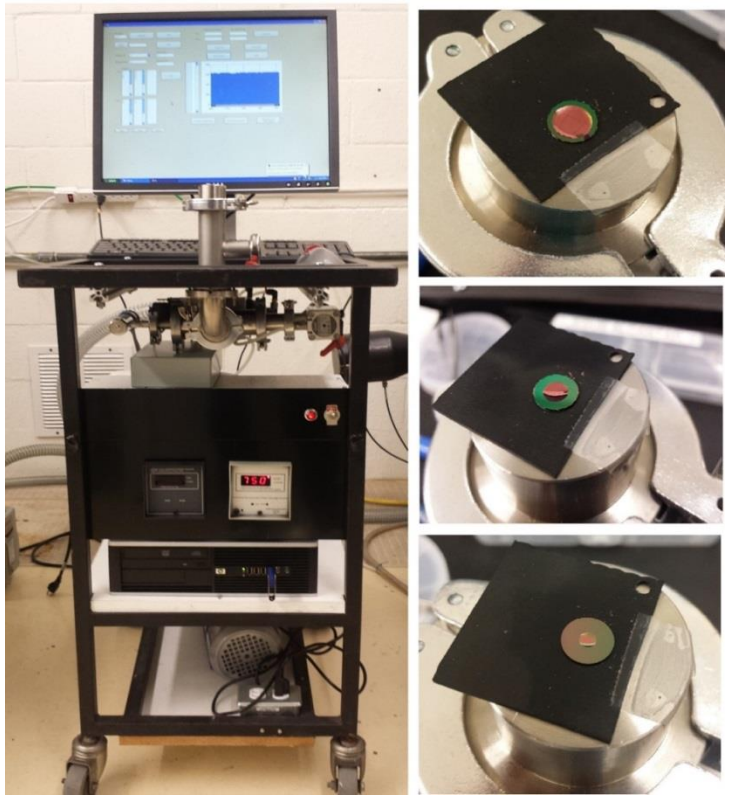




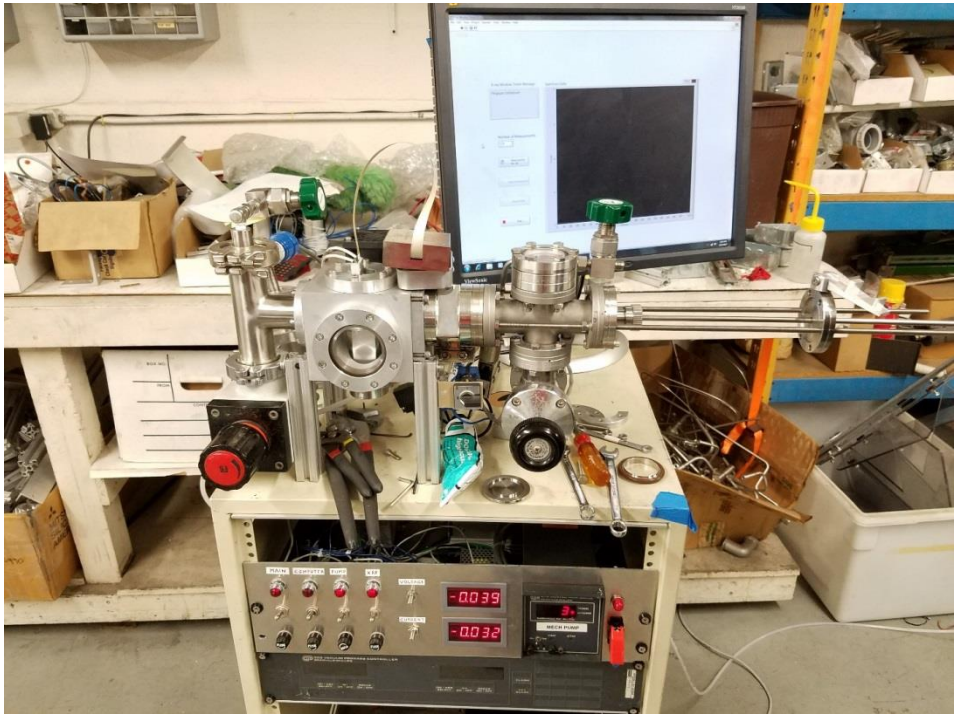




Proprietary Window Testing Equipment

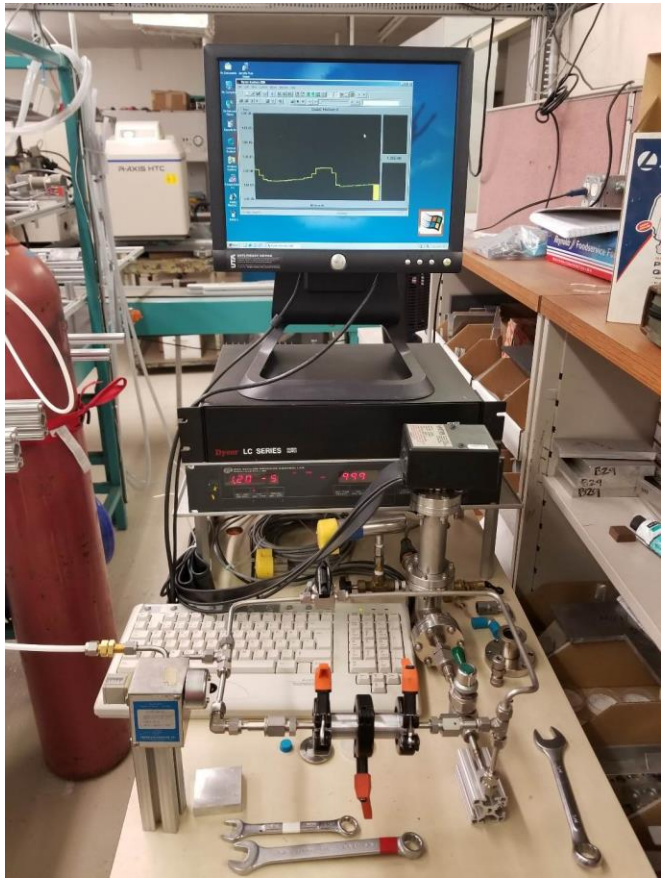


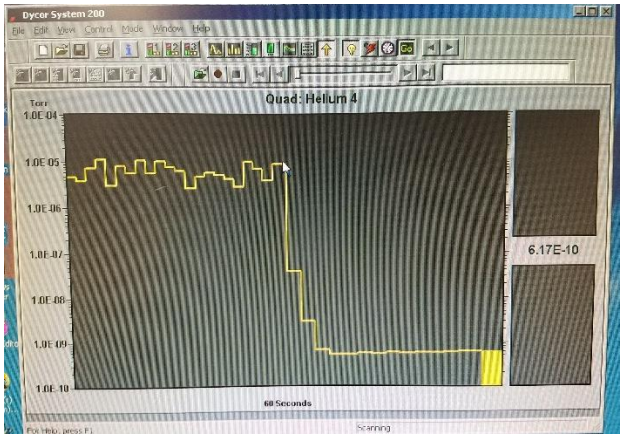
Vacuum Cycling and Leak Tester

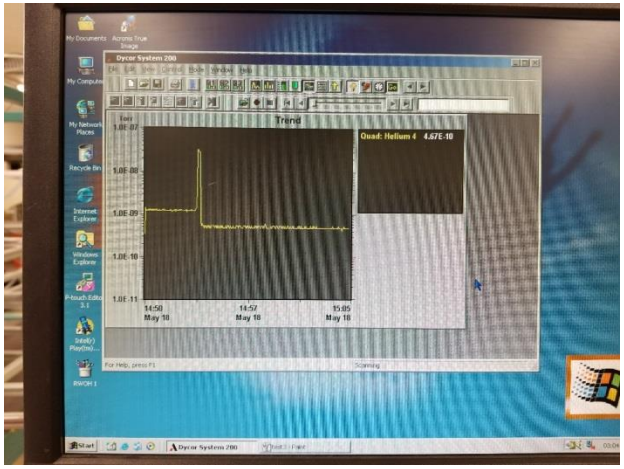


X-Ray Transmission Tester

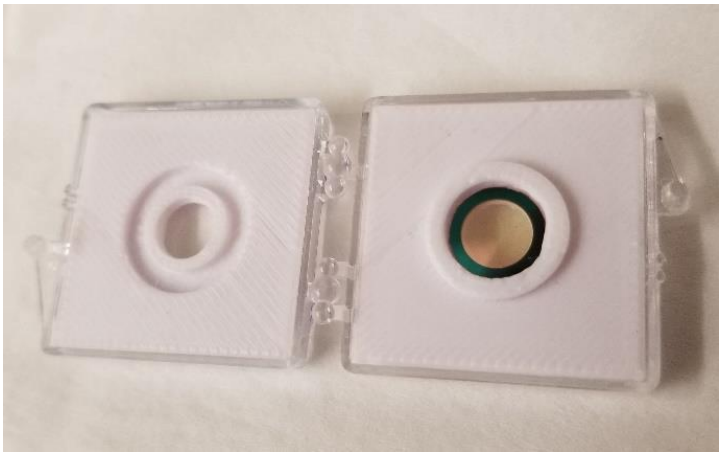
Leak Testing of Diamond Windows







Photos of Diamond Windows



Phase II Accomplishments

- Project ended successfully in October 2017.
- Obtained $500,000 additional funding from State of Kentucky for product development and marketing.
- Successfully demonstrated longer lifetime for 100 layer diamond stripper foils than previously best foils.
- The 100 layer diamond Stripper Foil Manufacturing facility is operational and is providing foils to NP Community
- Successfully fabricated diamond and silicon nitride x-ray windows for high performance low energy x-ray detectors
- Currently building partnerships with x-ray detector manufacturers to integrate x-ray windows in their spectrometers.

CALL US WITH YOUR REQUIREMENTS