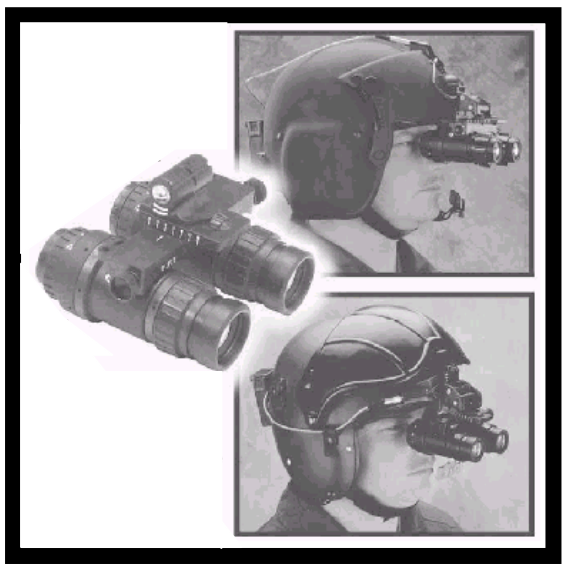
JDSU Large Optics Coatings Overview

31 July 2007

History: Custom Optics

was founded in 1948 by Rolf Illsley



- Initial products were antireflection coatings for military applications
- Acquired in 2000 by JDSU

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Covering Diverse Markets and Applications

- **Aerospace and Defense**
  - Military
  - Aviation
  - Space
- **Instrumentation**
  - Biomedical
  - Environmental Monitoring
  - Semiconductor
  - Intelligent Lighting
  - Test & Measurement
  - Food Analysis
  - Laser Optics & Components
- **Consumer & Commercial Electronics**
  - Office Automation
  - Televisions
  - Projection Devices
  - Digital Imaging
- **Communications**
  - Telecom & Datacom
- **Other**
  - Universities
  - Research Labs

Defense: Electronic Countermeasures

Space: Solar Cell Cover Glass

Night vision/ Surgical Goggles

Test & Measurement

Environmental Protection: Gas Sensing

Biomedical Anesthesia Monitoring

Consumer Electronics Office Automation

Consumer Electronics Televisions

Display panels

Intelligent Lighting

Telecom DWDM Mux/DeMux

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Decades of Precision Optics

- Leader in precision thin film coatings
  - Optical design, extensive thin film modeling
  - Coating equipment design & development
  - Coating and optical fabrication implementation
  - Large optic facility and tooling handling support
  - Metrology development & implementation
  - Complex program management capability
- State-of-the-art materials characterization lab
- ITAR and classified clearances
- ISO 9001 and AS 9100

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General Coating Capability

- Variety of coating chambers, processes and configurations
  - Ranging in size from 48 to 120 inches
  - High-volume continuous coater
  - Thermal, E-beam, IAD, IBS, DC/RF Magnetron, MetaMode™ & Ucp-1

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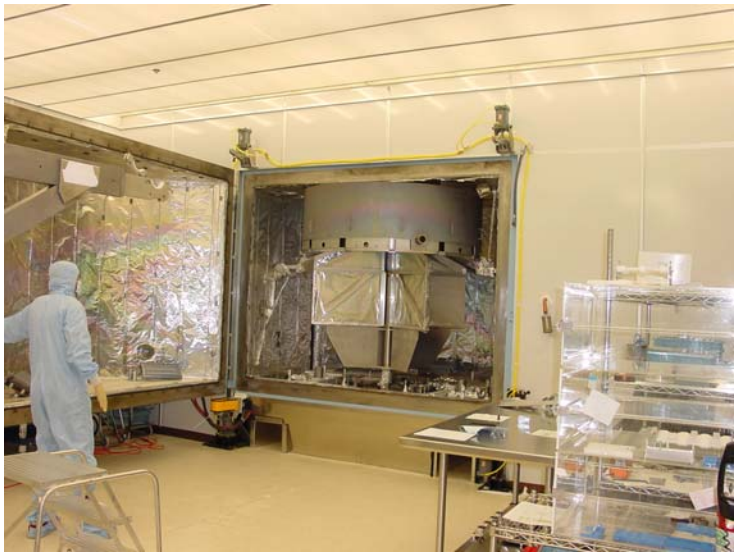
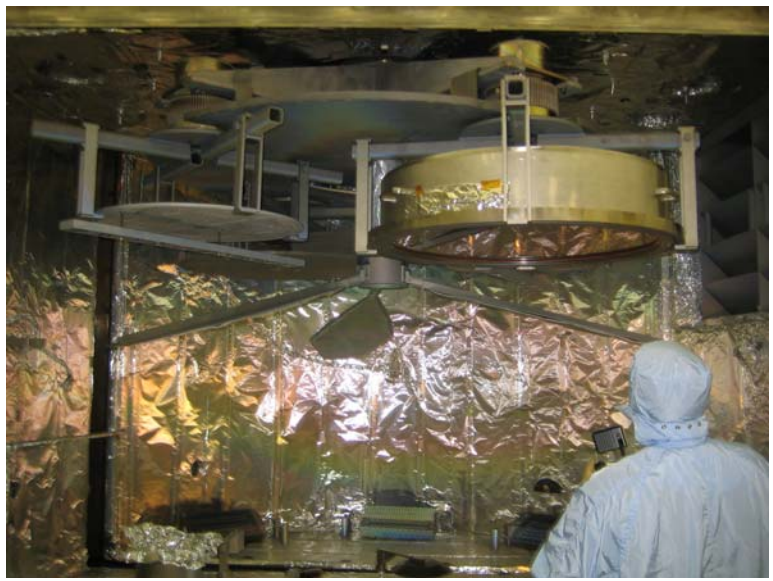
Large Optics Coating Capability



100 and 120 inch diameter chambers



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Large Optics

Overview

Decades of Large Optic Coating

[late 70s]

ALL

High Laser Damage Threshold CW 10.6 µm

[early 80s]

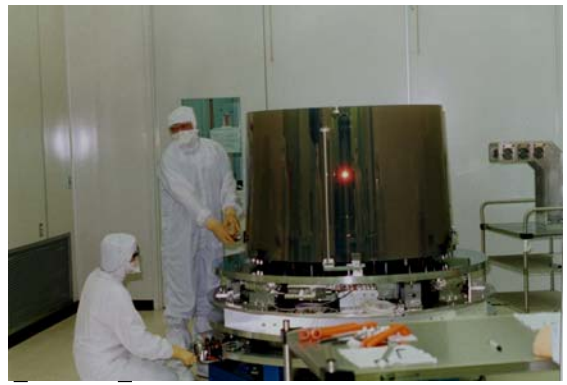
MIRACL
SLBD

High Laser Damage Threshold CW 3.8 µm

[80s]

NOVA

High Laser Damage Threshold Pulsed 1.06 µm



ALPHA

Phase retardance control

[mid 90s]

AXAF

Contamination control

ABL

[2000-2007]

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Large Optic Program Examples

- Sea Lite Beam Director
  - 1.8 m diameter

- NOVA ICF Optics
- Numerous 95 and 104 cm diameter glass substrates

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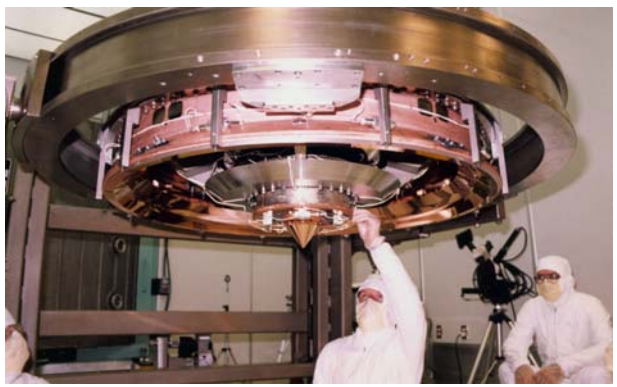
ALPHA Laser Resonator Optics

- Two 60 inch outer optics (one has 2 surfaces)
- Two inner cones (required extreme control of coating thickness for phase retardance)
- Automated cleaner
- Universal Handling Ring for Interface control
- Specialized Lift Truck for moving optics
- Developed extensive metrology instrumentation (R, T & A)



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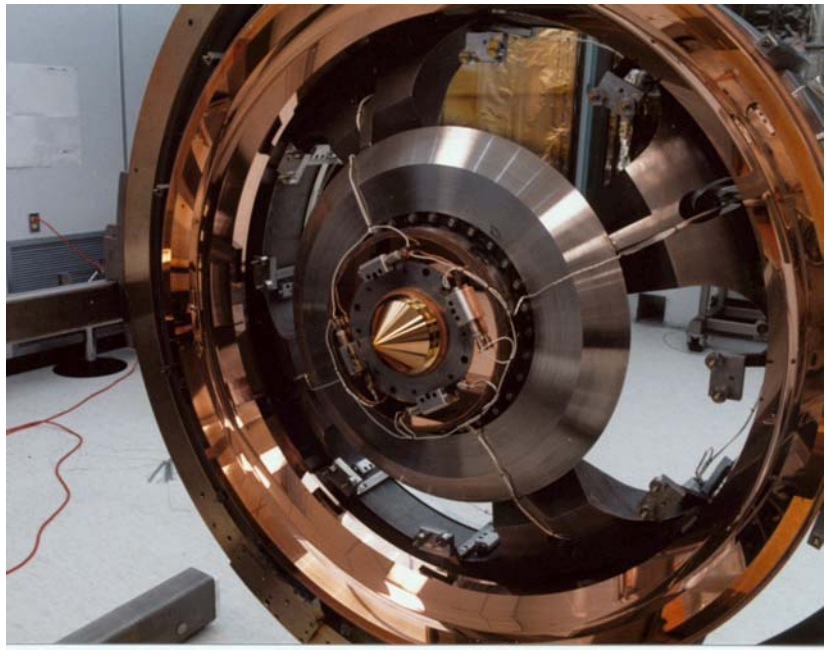
ALPHA Laser Beam Compactor

Beam Compactor in Cleaning Facility



SPDT Copper Surfaces, Mo heat exchangers

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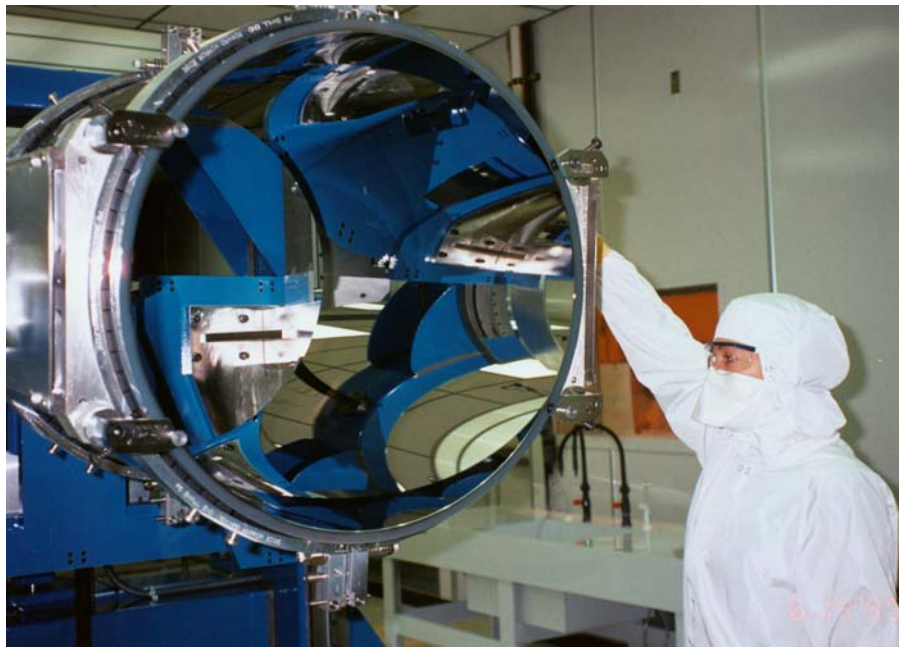
AXAF / Chandra Mirrors

- Eight cylindrical shells (24 to 48 inch diameter)
- Extreme emphasis on surface smoothness and contamination control
- Universal Handling Fixture for Interface control
- Specialized Lift Truck for moving optics



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AXAF Handling Fixture

Tensile stress maintained < 750 psi
for all orientations

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AXAF Cleaning and Coating

- Detergent & De-Ionized Water
- Rotating PVA Swab cleans mirror interior
- Flexible Shrouds prevent wetting of mirror exterior

- Stainless steel shields prevent coating of exterior
- Witness samples above & below mirror

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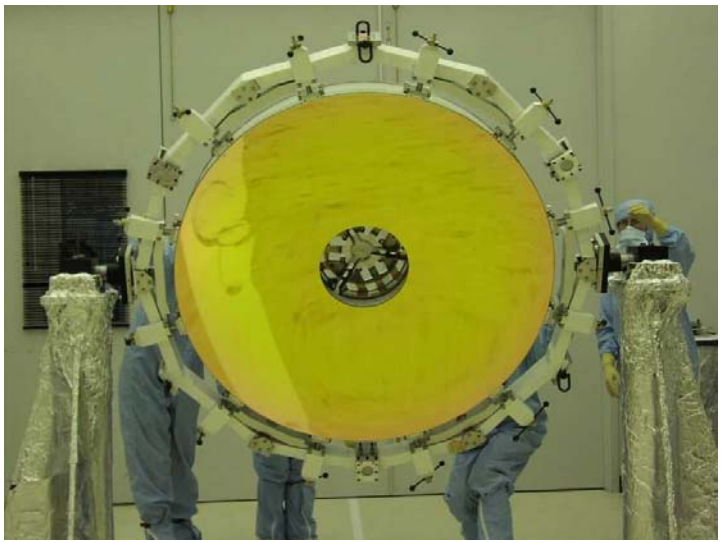
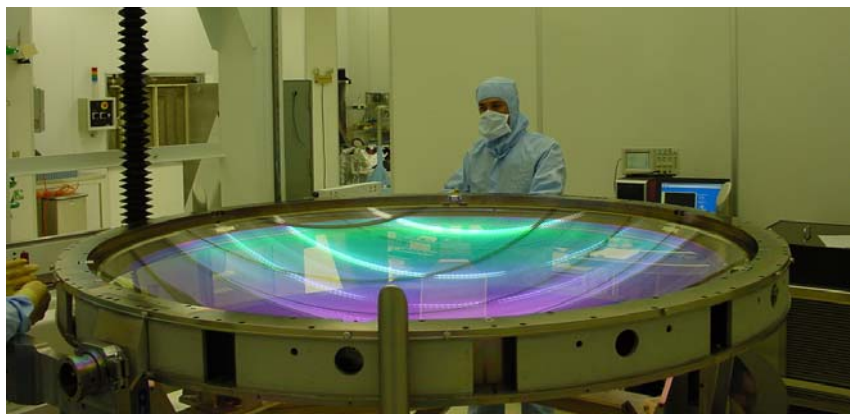
Airborne Laser Optics



- ABL Primary Mirror
  - Handling tooling developed to hold mirror from center hole
  - 100% clear aperture
  - Uniformity controlled for angle of incidence variation across mirror

- ABL Conformal Window
  - Tooling designed to accommodate large window sag
  - Coating uniformity tailored to compensate for phase and spectral performance over window curvature
  - Achieved < 40 ppm absorption



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Material Characterization Laboratory

Standard Test & Measurement

- Spectrophotometers
  - Cover UV, visual, near IR and IR
  - Measure wavelengths from 0.2 to 50 µm
  - Measure R and T at continuous angles
- Laser Photometers
  - Measure R and T at 1.06 and 1.319 µm
- Cryogenic to high temperature spectral measurements
  - Cover 25^{o} to 353^{o}K
- Environmental Chambers
  - Variable climate humidity and salt fog
- Calorimeters and Ring-Down Loss systems measure absorption/losses down to 10 ppm
- Interferometers for surface flatness and quality measurements

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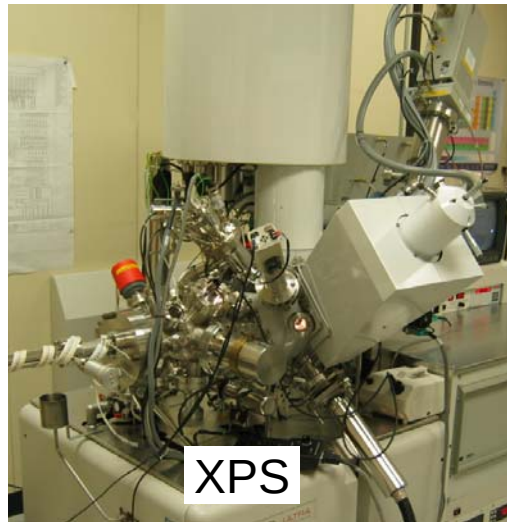
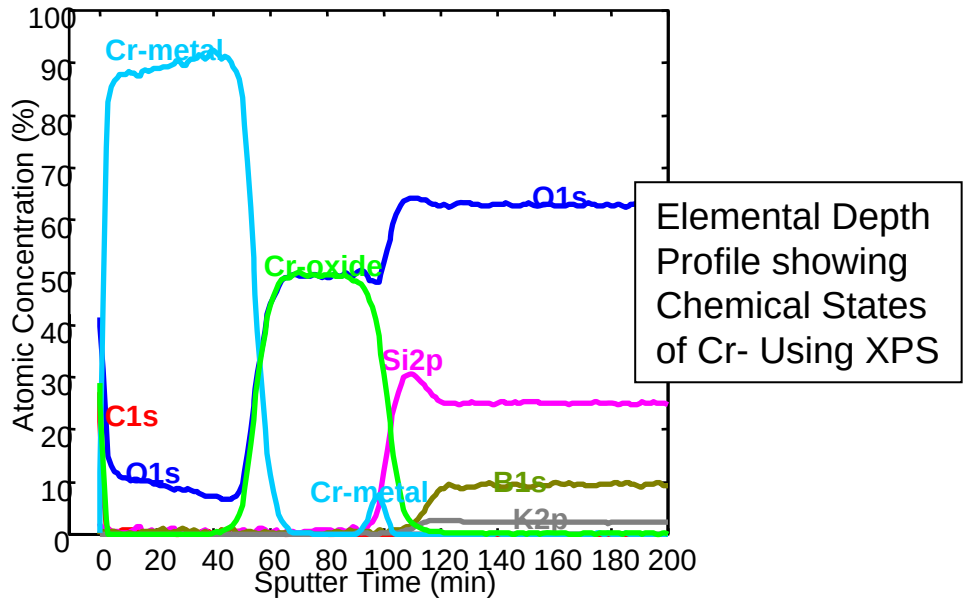
Advanced Materials Characterization

- Microscopy
  - SEM, TEM, SPM, Optical
- Micro-Analysis
  - EDX, WDX
- Electron Spectroscopy
  - XPS
- Mass Spectrometry
  - SIMS
- Depth Profiling
  - RBS
- Optical
  - Ellipsometry, Calorimetry
- Miscellaneous
  - Hardness, Hall Probe


FasTEM


XPS



Elemental Depth Profile showing Chemical States of Cr- Using XPS

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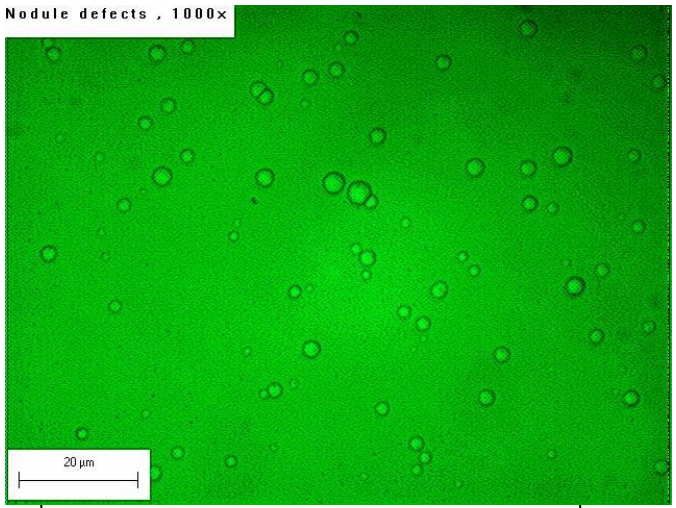
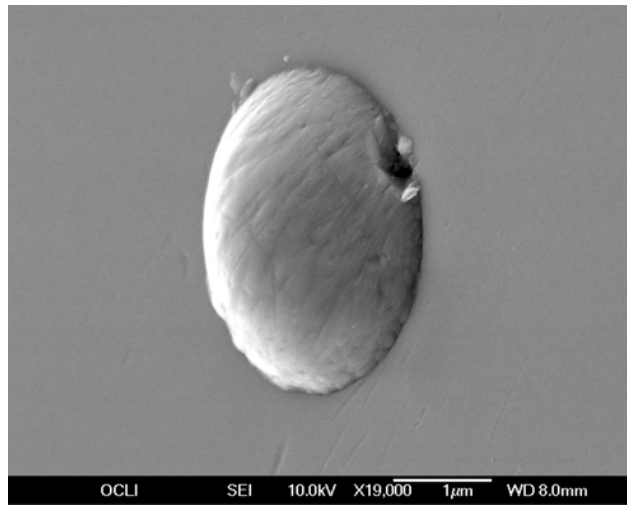
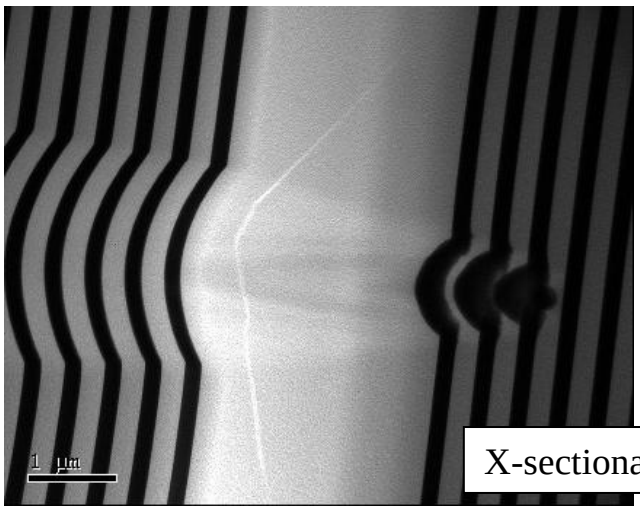
Materials Analysis: Surface Defects

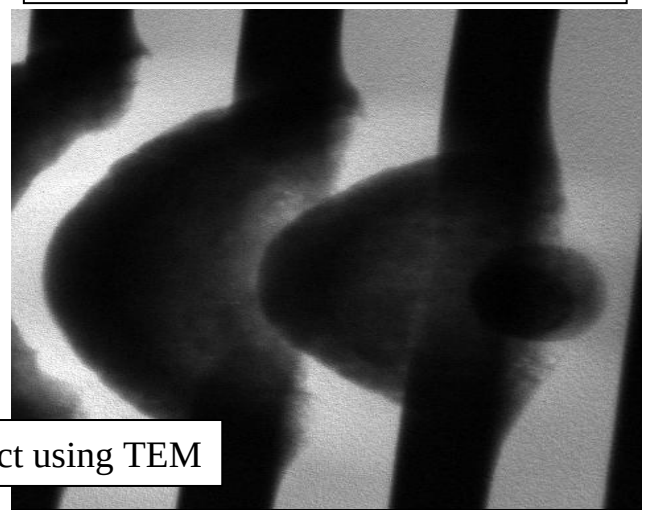


Nodular Defect Image Using LM



Nodular Defect Image Using FESEM





X-sectional image of nodular defect using TEM

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Summary

- JDSU has an established large optic coating legacy
  - Thin film design and coating development
  - Tooling design, construction and implementation,
  - Optic handling/cleaning
  - Coating chamber and deposition development and execution
  - Custom metrology design and support
  - Management of complex program requirements
  - Decades of large optic expertise

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