



Liquid Penetrant Testing at Goddard Space Flight Center

INTRODUCTION TO NATHAN A. SMITH, MATERIALS AND PROCESSES
ENGINEER IN THE MATERIALS ENGINEERING BRANCH AT GODDARD
SPACE FLIGHT CENTER

About me

12 years supporting NASA in the area of Materials and Processes, but newcomer to Nondestructive Evaluation (NDE)!

Lead Materials and Processes (M&P) Engineer at Goddard Spaceflight Center for multiple spaceflight missions and instruments since 2010.

James Webb Space Telescope

ExoMars 2020, Mars Organic Molecular Analyzer Instrument

Various past missions in satellite servicing, space-based communications, Earth science, and planetary science.

M&P subject matter expertise development

Liquid Penetrant Inspection(!!!!)

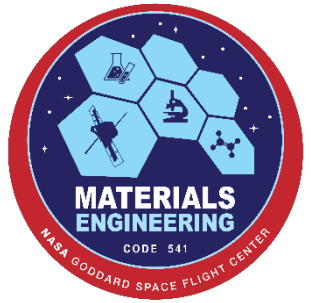
Adhesive bonding of optical components and assemblies

Vacuum furnace brazing

Service support contractor at Marshall Space Flight Center from 2007-2010 supporting solid rocket nozzle high-temperature ceramics and ablatives for the Space Shuttle solid rocket booster nozzle and the Constellation Program Ares 1 first stage booster nozzle.

B.Eng., Polymer and Fiber Engineering, Auburn University, 2007





Liquid penetrant testing at GSFC

OSMA Agency Nondestructive Evaluation (NDE) Program

Flight Project Applications

- International Space Station Payloads in accordance with fracture control requirements
- Welded flight components in accordance with American Welding Society (AWS) specifications
- Single-point failure components
- Propulsion systems and cryogenic systems
- New applications of metal-matrix composite materials with controlled low thermal expansion and/or high specific stiffness

Flight project customers

- Robotic Refueling Mission, Astronaut Servicing Tools, X-ray Imaging and Spectroscopy Mission (XRISM), Europa Clipper, Wide-Field Infrared Survey Telescope (WFIRST), Laser-Enhanced Mission and Navigation Operational Services, and many others!

Liquid penetrant testing research areas

- Penetrant testing (PT) of additive manufactured parts
- Radiocontrast materials for enhanced x-ray contrast
- Penetrant testing of externally threaded fasteners
- Innovative pre-treatment methods for parts prior to PT
- Unique flawed specimens (e.g. NOT FLAT PANELS!)
- Penetrant testing of low expansion metal-matrix composites
- Effective post-cleaning of parts after penetrant testing in contamination sensitive applications

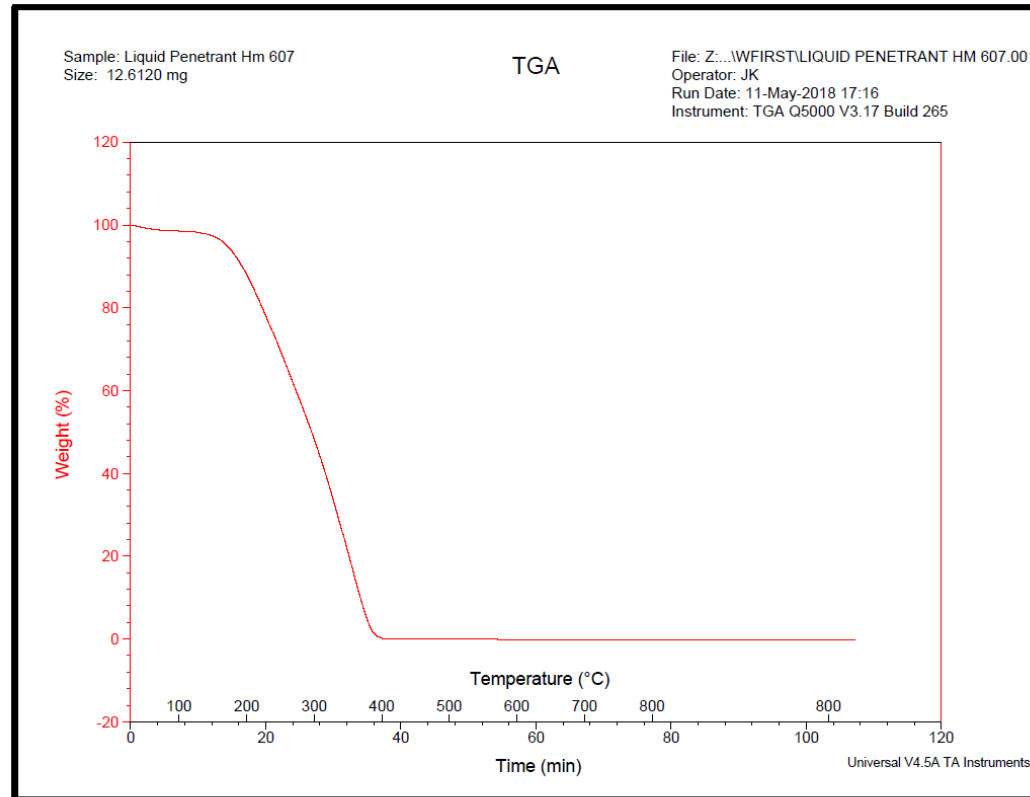
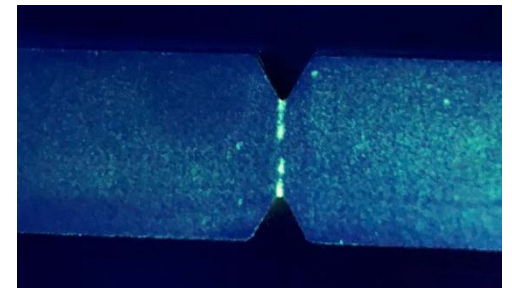
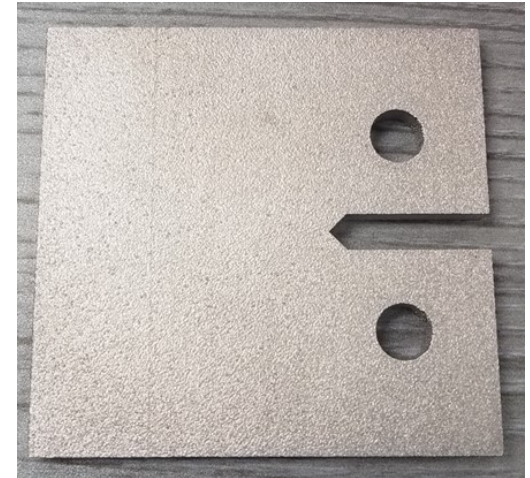
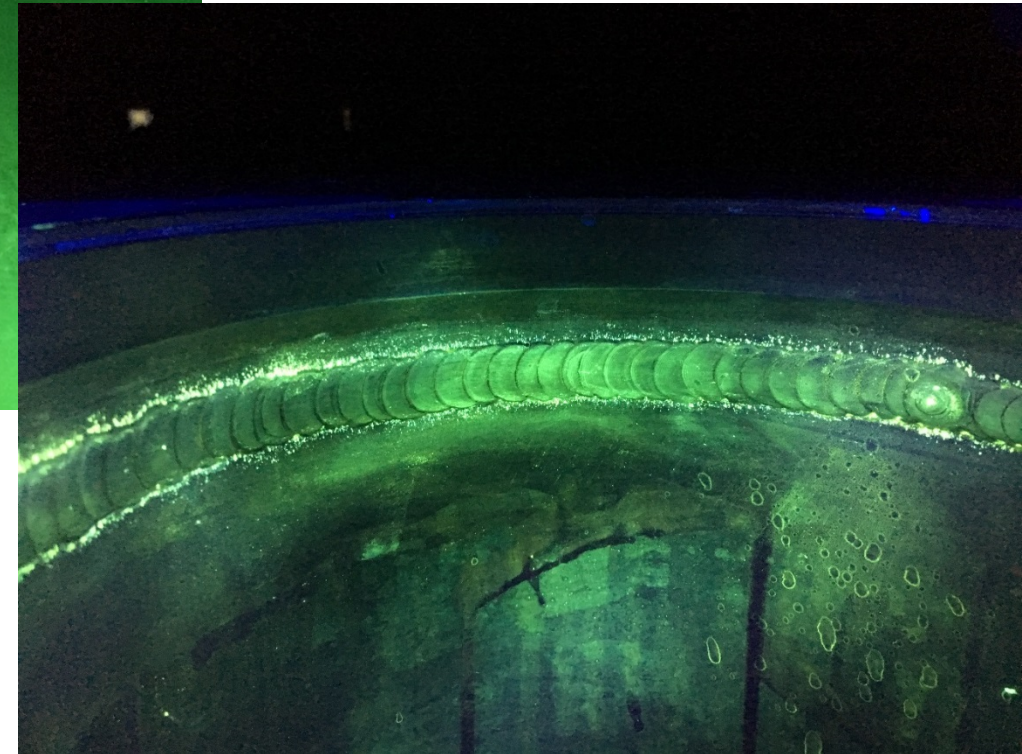
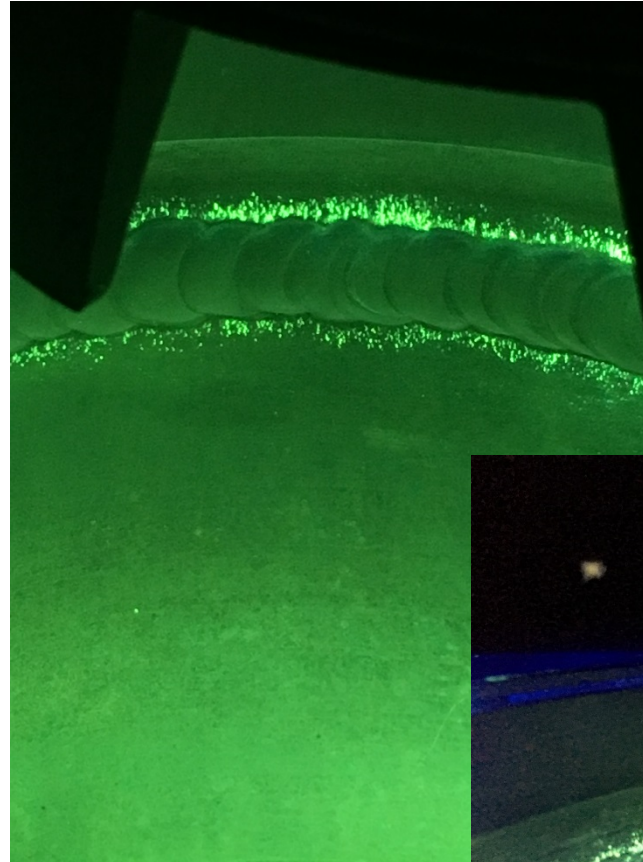


Figure 1. TGA of Sherwin HM-607 Fluorescent Penetrant.



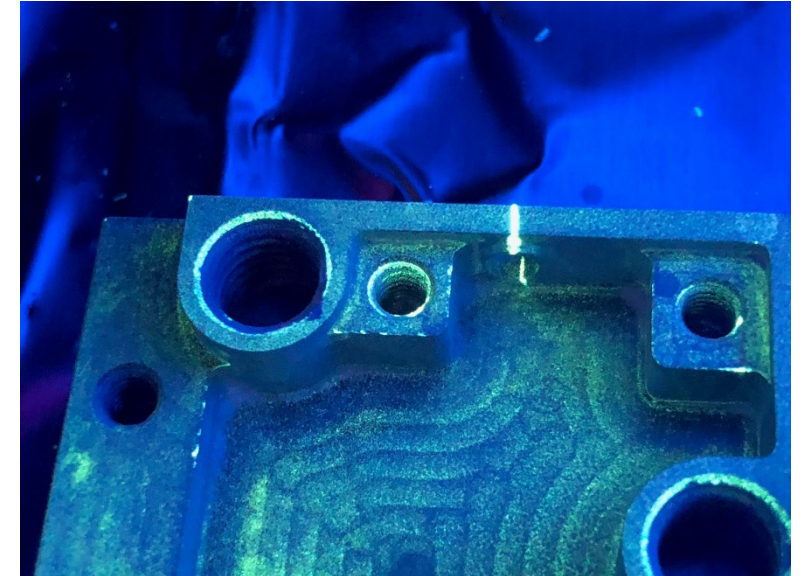
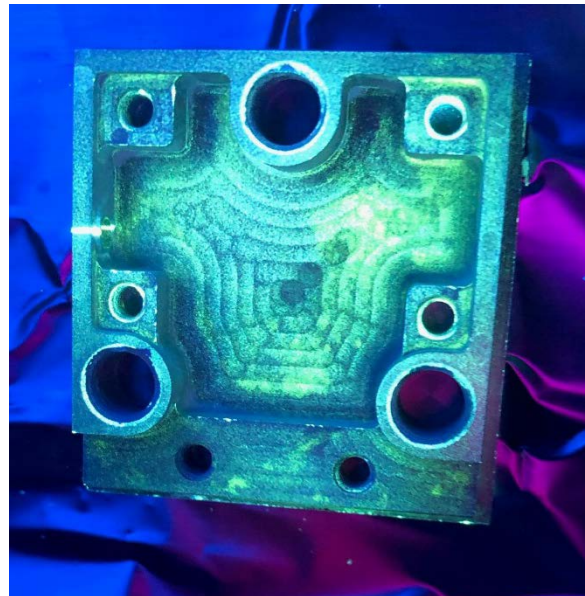
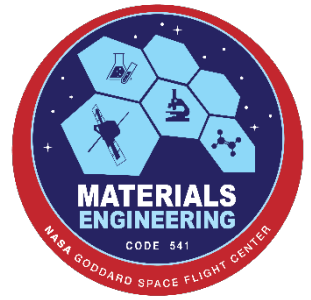
Flight Application- XRISM: Weld HAZ Indications

- Issue: Welded aluminum ground support equipment with indications observed in the heat-affected zone of the weld
- The welding technician suggested the indications could be removed with a Scotchbrite abrasive pad
- NDE concern that Scotchbrite was just smearing metal and hiding the features which were still present in the HAZ
- Concern was confirmed with testing. Features were not removed with Scotchbrite, only masked
- Image of initial indications (left) and image of indications after Scotchbrite and subsequent etch (right)



Flight Application- WFIRST: Mosaic Plate Material Trade

- The plate that holds the detectors for the WFIRST Wide Field Imager require the use of a low-expansion material
- Sandvik-Osprey CE-6 controlled expansion Aluminum-Silicon metal-matrix composite was studied for usage
- Material is extremely brittle (behaves much like ceramic) and is susceptible to damage during manufacturing
- Penetrant testing was explored as a means to screen defects or damage early in the processing to eliminate schedule loss associated with subsequent processing of a damaged part
- Penetrant testing proved one of the most sensitive and quickest NDE techniques for crack detection. Interesting finding: Material surface is essentially covered with microscopic cracks, which results in a high background fluorescence



Meet the GSFC NDE team!

- I'm just a small part of a terrific NDE team at GSFC, comprised of a mixture of new talent and experienced experts (pictured left to right)
- Justin Jones- Branch Lead NDE Technologist
- Ryan Kent- NDE data analysis and artificial intelligence/machine learning applications
- Chris Hoffman (Ball Aerospace)- Ultrasonic, flash-infrared thermography, radiography
- Nathan Smith- Liquid penetrant testing and flight project applications
- Olivia Landgrover- Cryo-CT, Flaw specimen concepts
- Grace Fischetti- Digital radiography (real-time and computed tomography)
- Bruno Munoz (Ball Aerospace)- Digital Radiography (real-time and computed tomography)
- Antonio Moreno- Ultrasonic testing, eddy current, certified welding inspector (not pictured)

