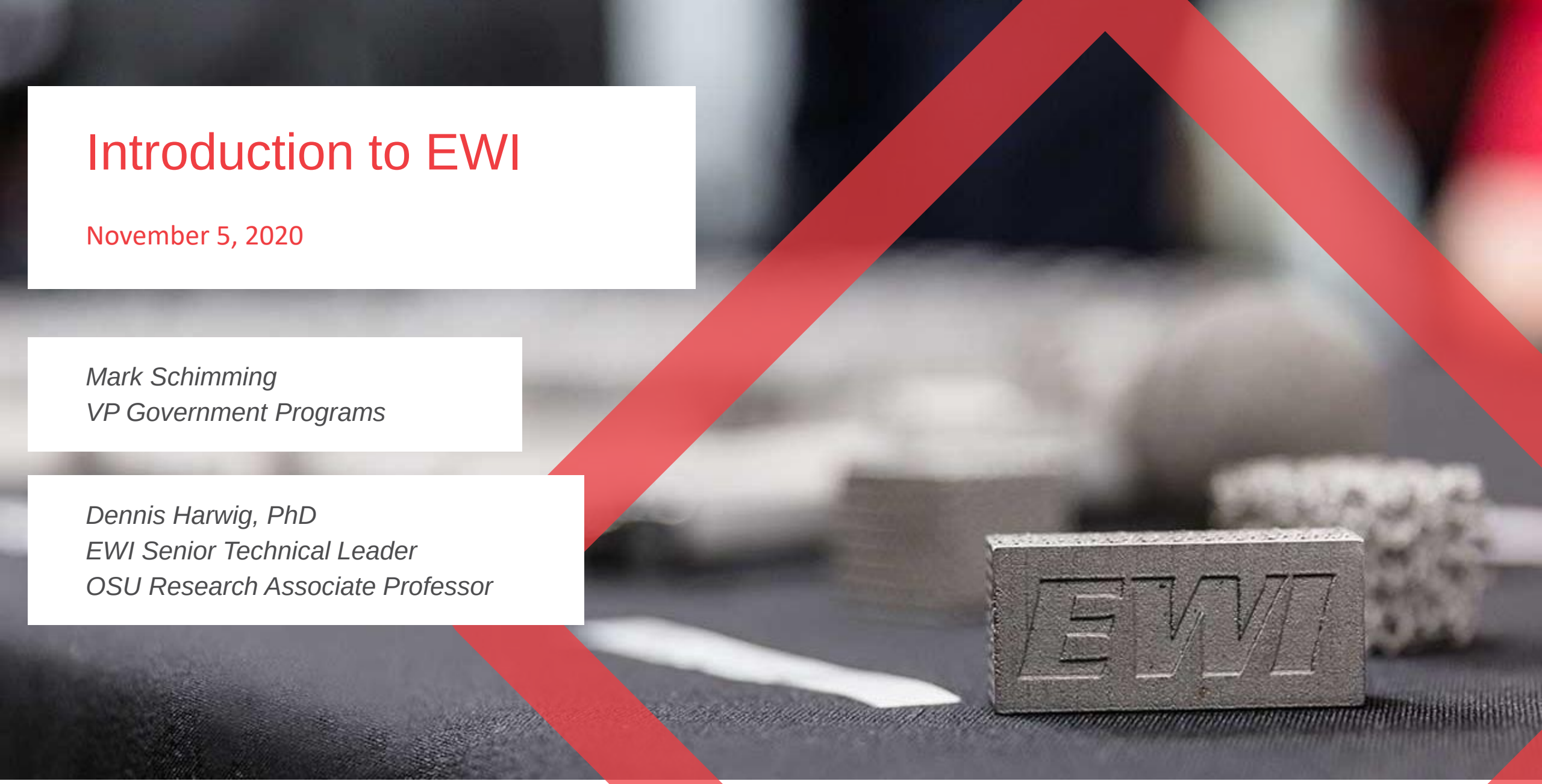
Introduction to EWI

November 5, 2020

Mark Schimming
VP Government Programs

Dennis Harwig, PhD
EWI Senior Technical Leader
OSU Research Associate Professor



EWI®
We Manufacture Innovation

About EWI

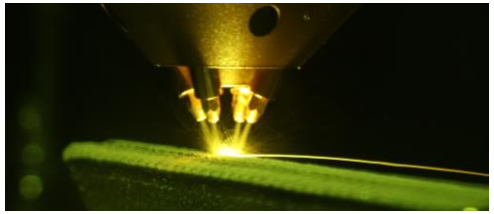
- Independent, self-sustaining manufacturing technology center of excellence
- Mission to deliver innovative technical solutions in manufacturing processes that elevate our customers' competitiveness
- Serving broad range of manufacturers and government agencies for 35 years
- Leading edge in many important manufacturing technologies
- Transitioning technology to improve product performance, quality, reliability, and cost
- Introducing new services to help small and medium size manufacturers innovate
- Building public-private partnerships around key industry challenges

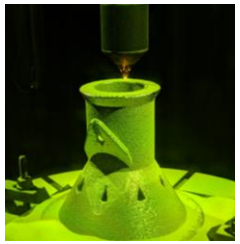
Federal Programs

- Serving diverse agencies: Navy, Army, Air Force, DOE, NASA, DoT, etc.
- U.S. Navy is EWI's largest single customer
- Member of 5 Manufacturing USA Institutes
- Collaboration examples:
  - Navy ManTech/Center for Naval Metalworking: Technical partner
  - LIFT: Founder and execution partner
  - America Makes Technical Roadmap committee - RMAG
  - Army: CCDC/ ARDEC/ ARL
  - Air Force: SBIR projects
  - NIST: AM Test Bed Development
  - NSRP: Telepresence Welding Development, Arc Based DED
  - DOE: Machine Learning Enhanced AM DED of Function Gradient Materials
  - ASTM Additive Manufacturing COE: Partner with NASA/Auburn

Federal Project Examples

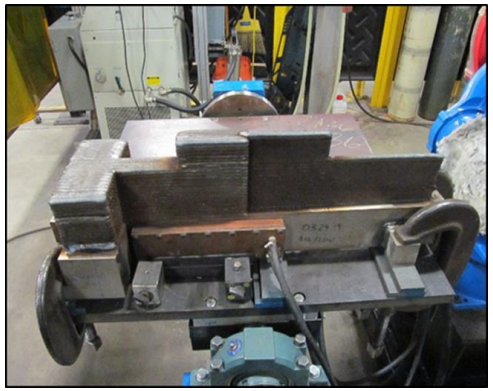
MANTECH: F35 Ultrasonic Boot Cutter implemented in ~6 months, ~3X productivity improvement, savings >$10M's, Collaboration with Lockheed Martin





America Makes MAMLS: Feature Based Qualification for Laser-DED AM, Collaboration with GE and Raytheon

MANTECH: implemented robotic welding of interim products for Virginia class sub., ~$1.2M savings per hull, multiple follow on applications



NAVSEA: Developing Navy Tech-Pub for robotic Arc-DED AM material/process qualification requirements

Public-Private Partnership Experience

- Useful EWI attributes for public-private partnerships
  - Independent non-profit company
  - Experience in convening diverse groups
  - Deep industry, academic, government relationships
  - National reach with locations in multiple states
  - Flexible contracting and intellectual property approach
  - Government contracting and program management infrastructure
  - Proven track-record in technology transition and commercialization with small, medium, and large companies

Additive Manufacturing Consortium
Operated by EWI

EWI Forming Center Consortium

EWI Strategic Technology Committee
Oil & Gas

Nuclear Fabrication CONSORTIUM
Operated by EWI

ASTM

CENTER of EXCELLENCE
Research to Standards

CNM
CENTER FOR NAVAL METALWORKING

lift
LIGHTWEIGHT INNOVATIONS FOR TOMORROW

BUFFALO MANUFACTURING WORKS
Operated by EWI

NAVY JOINING NJC CENTER

AMRO AEROSPACE MAINTENANCE & REPAIR ORGANIZATION
Center of Excellence

Through-Transmission Laser Welding of Continuous Fiber Reinforced Thermoplastic Composites

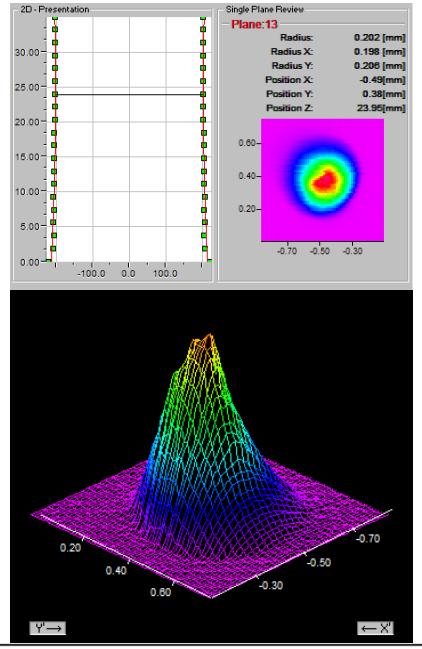
Objectives:

- Join thermoplastic composites using a processing method that is reliable, consistent, and scalable.
- Yield weld joints that are strong, lightweight, and durable.
- Fabricate structures and vehicles without mechanical fasteners that lighter, stronger, and free of stress concentration/corrosion issues.

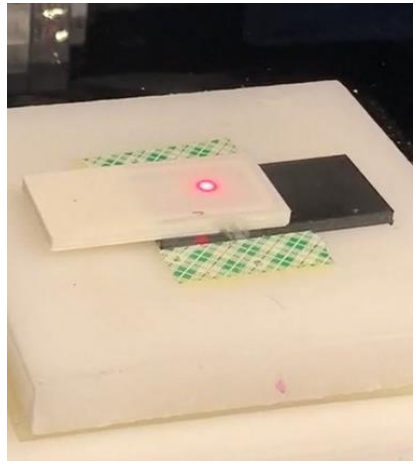
Project Team:

- EWI Internal Research and Development

Understand Beam Profile and Limitations



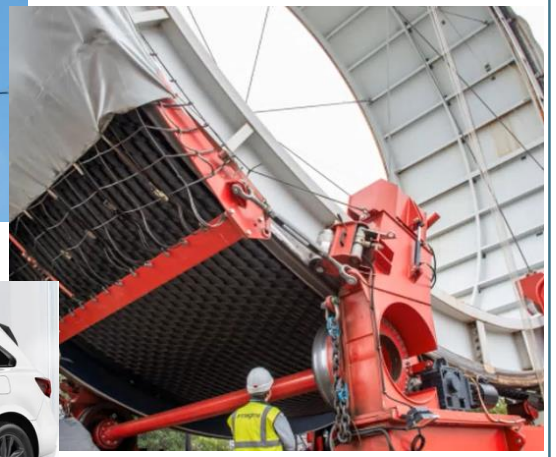
Weld Specimens with Various Fiber Type and Layup Geometries



Perform Mechanical Testing

- **Applications**

Oil & Gas



Automotive

Tele-Welding
Remote Operation of Shipyard Welding

Challenge: Increase the Welding Workforce

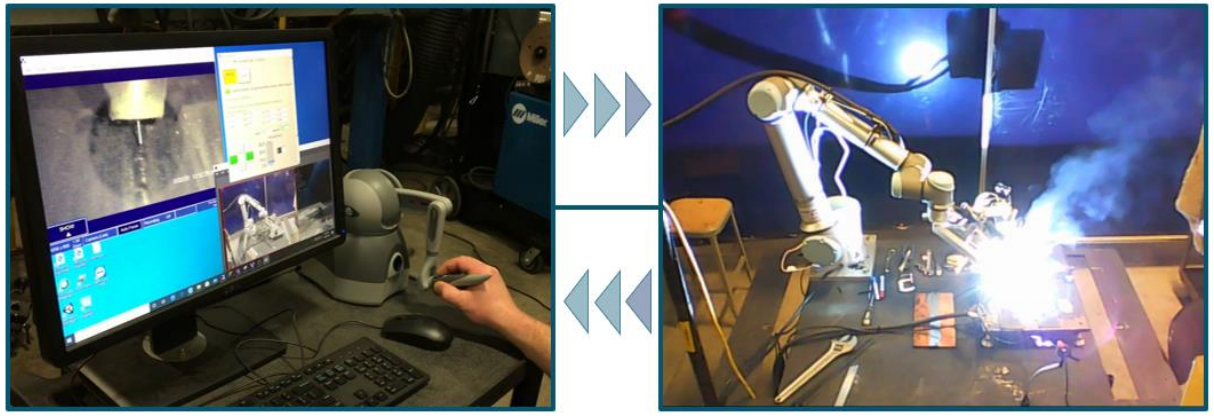
- Empowers persons of all ages and/or limitations to become productive
- Attacks the loss of skilled welders
- Transforms welding to a high-tech career
- Isolates welders from the hazards of dark, dirty, and dangerous welding operations

Solution/Approach

- Year 1 **Complete**: Investigated technologies that provide full control of welding operations while remote from the arc
- Year 2 **Ongoing**: Merge technologies into existing mobile welding platforms
    - Demonstrate on shipyard-selected representative joints
    - Allow shipyard welders to experience tele-welding in the shipyard

Objectives

- Develop a system that allows workers to operate welding equipment from a remote location yet be in complete control of the welding process
- Create a method for workers to gain exposure and confidence in tele-presence manufacturing, and guide future efforts in remote-controlled manufacturing technologies
- Allow anyone, anywhere to be active participants in manufacturing enterprise



EWI
We Manufacture Innovation

Team: EWI | RTT | HII-NNS | GDEB | Visible Welding

Automated Repair for Aerospace Component

Challenge: Automate a Specialized Manual Process

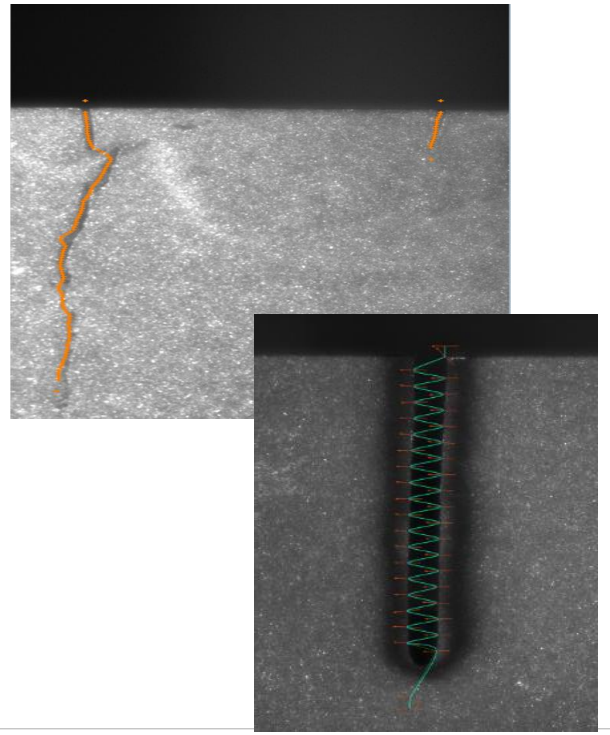
- Manual GTAW repair of the component was intensive and required an experienced, high-skilled labor force
- Regions where the repairs are completed have very small labor pool for the required skillset
- Different repair processes at different repair locations led to quality consistency issues

Approach

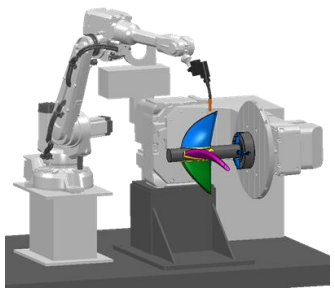
- EWI developed laser welding procedure
- EWI computer vision algorithm finds cracks, creates a laser path, then executes repair procedure
- EWI worked with an equipment integrator to deliver a turn-key solution to the client
- Reduced risk for client by performing shake out, qualification testing, and training at EWI

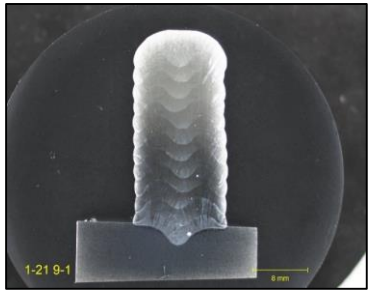
Objectives

- Automate component crack repair process
- Accommodate variations in material thickness
- Reduce reliance on limited supply of highly skilled trades



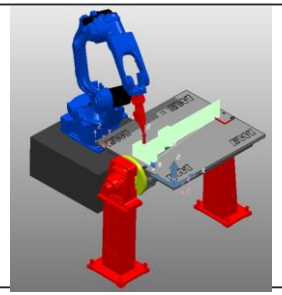
NSRP Robotic Arc Directed Energy Deposition (DED) Additive Manufacturing (AM) for Shipbuilding





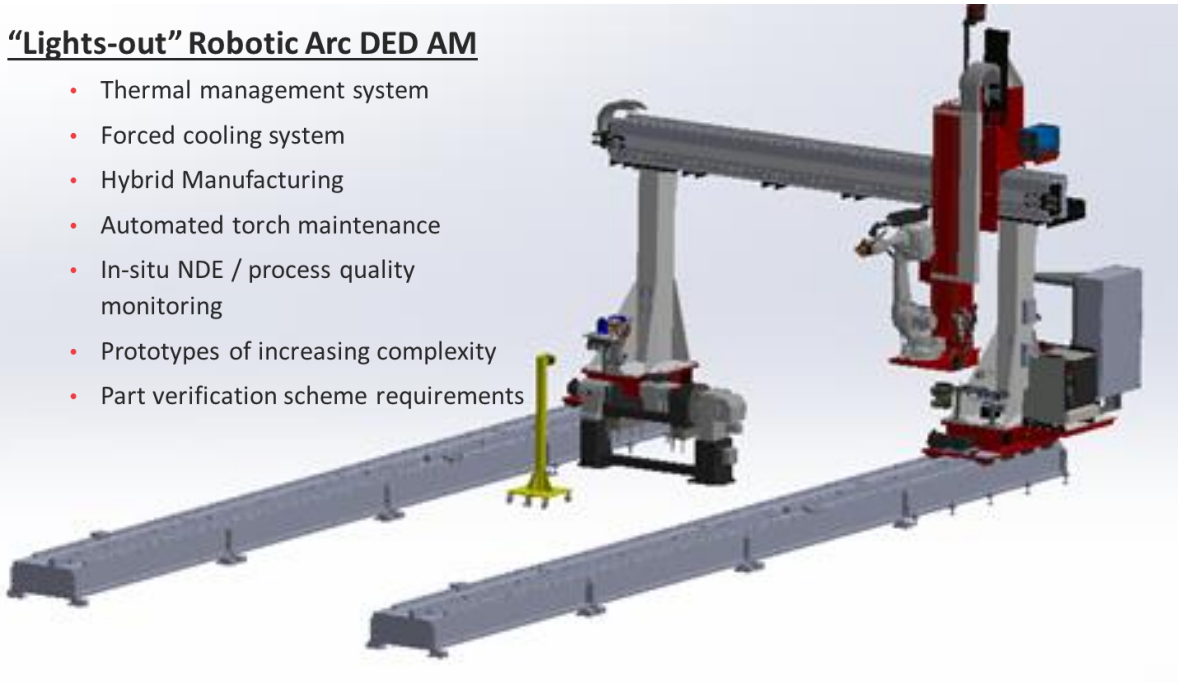
Project Team

EWI – Project PI
Navus Automation
Austal USA
NSWCCD
ABS



"Lights-out" Robotic Arc DED AM

- Thermal management system
- Forced cooling system
- Hybrid Manufacturing
- Automated torch maintenance
- In-situ NDE / process quality monitoring
- Prototypes of increasing complexity
- Part verification scheme requirements



Objectives:

- **Convert multiple robotic weld system to DED systems**
- **Design standardized large-scale gantry DED system**
- **Develop digital data workflow processes**
- **Develop advanced training materials - workforce**
- **Demonstrate representative qualifications**
- **Provide standardized equipment & services**
- **Build prototypes of increasing complexity**
- **Identify implementation opportunities**

Reducing barriers to implement DED AM

EWI
We Manufacture Innovation

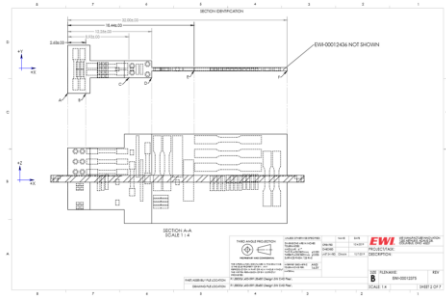
NSWCCD Process Qualification Scheme Development for Technical Publication – Metal Directed Energy Metal Additive Manufacturing

Objectives:

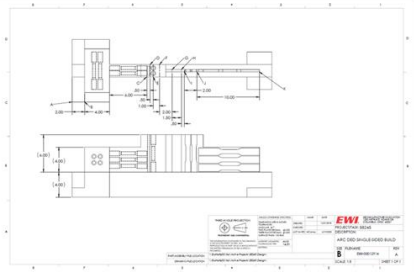
- Develop procedure qual. schemes / leverage welding standards.
- Develop material property data for common Naval materials - stainless steel, NiAl Bronze, advanced steels, titanium etc.
- Support development of NAVSEA Tech. Pubs – procedure and part build requirements for metal powder bed and DED processes

Project Team:

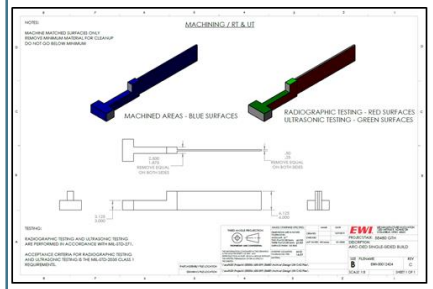
- EWI
- Naval Surface Warfare Center Carderock Division
- Technical Warrant Holder – AM NAVSEA 05T



Design



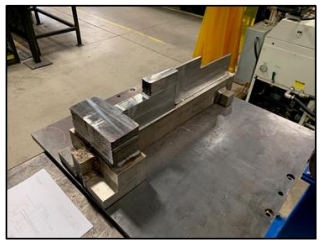
NDE



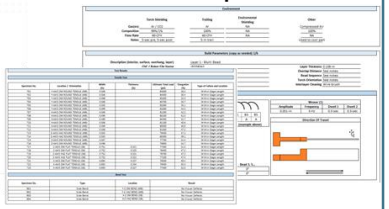
Build

Property Test

Machine



Report



- Each procedure qualification scheme consists of:
  - Standard qualification build (SQB) design
  - Nondestructive testing map
  - Property test specimen matrix
  - Procedure qualification test report (process specific)
- SQB application types include:
  - Single sided non-integrated build platform (SS-NIBP)
  - Single sided integrated build platform (SS-IBP)
  - Double sided integrated build platform (DS-IBP)
- Procedure qualification scheme portfolio - full-scale (FS), sub-scale (SS), and mini-scale (MS) features for the three SQB applications
  - Accommodate full range of DED (arc, laser, electron beam) process feature capabilities

EWI
We Manufacture Innovation

Additive Manufacturing at EWI

CAPABILITIES

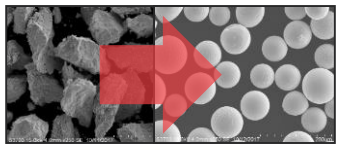
AM Training & Consulting Services
- Design for AM, Materials, Qualification, Specifications & Process Auditing

AM Applications Development
- Selection, Feasibility, Development & Certification Support

Advanced R&D
- New Material & Process Development
- Metallography and Testing
- Component Design & Prototyping
- Industrial Metrology & NDE
- In-situ monitoring, Closed loop control, Big Data analytics

RESEARCH

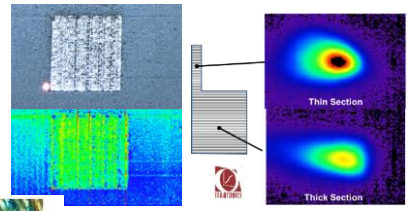
AM Powder Feedstock Optimization & Recycling



L-PBF Next Gen. Machine Qualification

AM Surface Roughness Optimization

L-PBF & L-DED In-Process Sensing



Consortia & Partnerships

Additive Manufacturing Consortium
Operated by EWI

America Makes

ASTM AM Center of Excellence

AUBURN UNIVERSITY

NASA

mtc

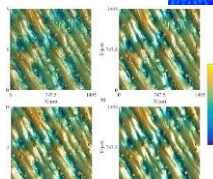
ADDITIVE EQUIPMENT

Laser & Electron Beam **Powder Bed Fusion**

Ultrasonic AM

Binder Jetting

Arc/Laser/E-Beam Powder & Wire **Directed Energy Deposition**



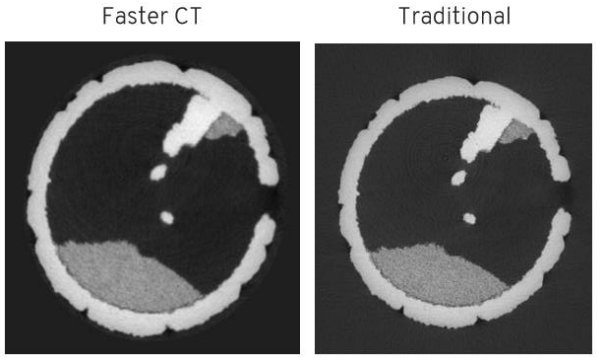
EWI ufacture Innovation

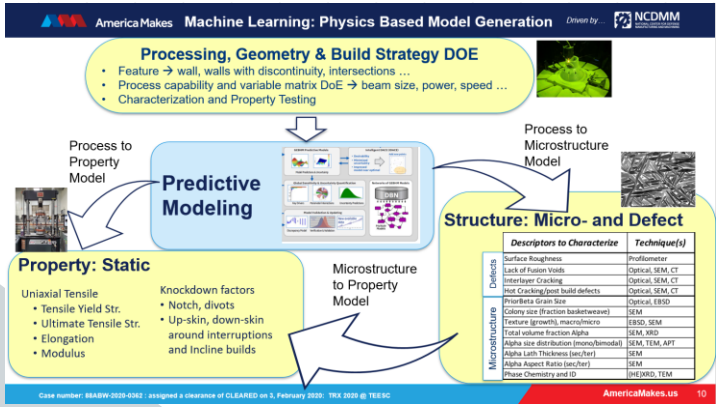
Technology Example: Metal AM Capabilities

- All 7 ASTM additive technologies in house
- Many support technologies for powder development, characterization, inspection, sensing, etc.
- Active projects in properties assessment, NDE, process optimization, process monitoring/control, powder characterization, surface measurement, post-processing, new materials, etc.

AM Equipment	Type	Build Volume
EOS M290	L-PBF Process	250x250x300mm
Sensor Test Bed	L-PBF Process	125x250x150mm
RPMI 577	L-DED Process	1524x1524x2133mm
Sciaky 110	EB-DED Process	1778x1194x1600mm
ExOne Innovent	BJ Process	160x65x65mm
Arcam A2X	EB-PBF Process	250x250x250mm
Fabrisonic	UAM	1800x1800X1200mm
Arc Wire Deposition	A-DED Process	>1000x1000x1000m
Laser Wire Deposition	L-DED Process	>1000x1000x1000m
Friction Stir Deposition	FS-AM	>1000x1000x1000m

How EWI Supports Qualification





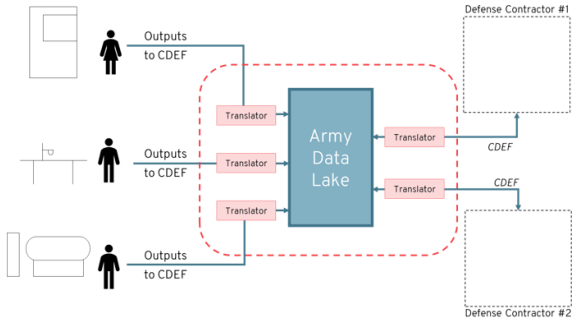
ML/ICME Based Qual

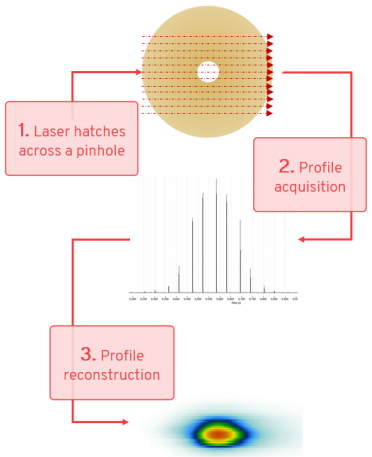
In-Process Inspection

Post-Process Inspection

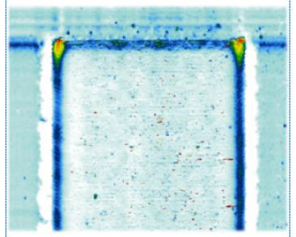
System Certification

Enable Data Ecosystem



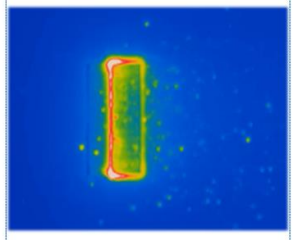


LASER PROFILOMETRY



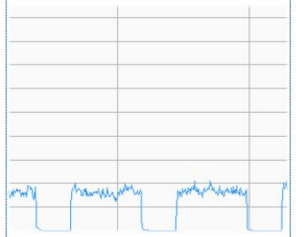
- **Keyence LJV-7060**
- **FoV**: 15 × 16 mm
- **Resolution**: 20 µm
- **Color**: Blue laser

IR BUILD AREA IMAGING



- **Micro-Epsilon TIM640**
- **FoV**: 130 × 90 mm
- **Resolution**: 200 µm/px
- **Frame Rate**: 32 fps

LIGHT INTENSITY

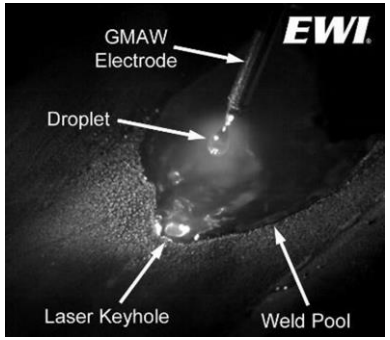


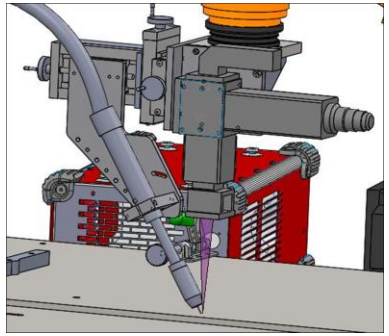
- **Thor Labs PDA36A**
- **Spectral:** 350-1000 nm
- **Gain:** 40 dB
- **Frame Rate**: 50 kHz

EWI®
We Manufacture Innovation

NSRP Thick Section Hybrid Laser Arc Welding for Shipbuilding

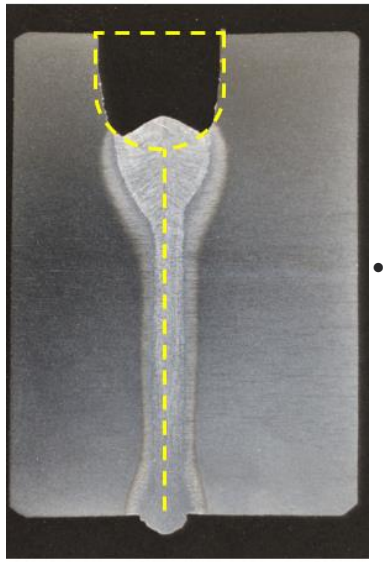
VIDEO





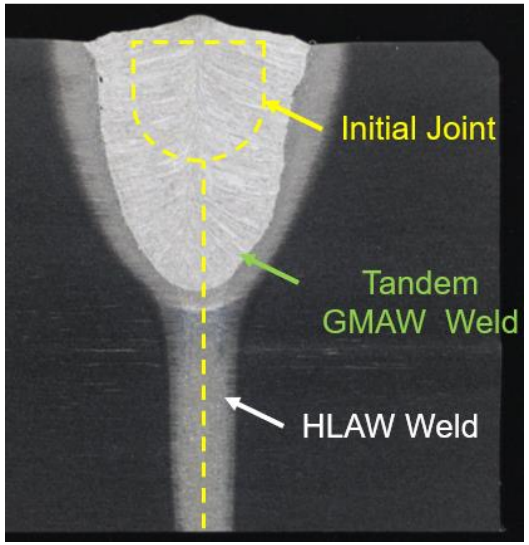
Project Team

EWI – Project PI
NASCCO
Ingalls
NSWCCD
BAE



Thick Section HLAW

- Full penetration
- Single Pass ¾-in Hybrid laser/GMAW weld
- 40-80 in/min welding travel speeds
- Reduced panel distortion and straightening requirements



Objectives:

- **Improve panel welding productivity**
- **Reduce distortion for Navy shipbuilding**
- **Design weld joint preparation for thick section HLAW process**
- **Evaluate the effect of tandem fill pass on mechanical properties**
- **Provide deliverable welds for shipyard evaluation**
- **Identify implementation opportunities and risks**

Evaluation of Candidate Methods for Welding Steel to Other Structural Lightweight Metals

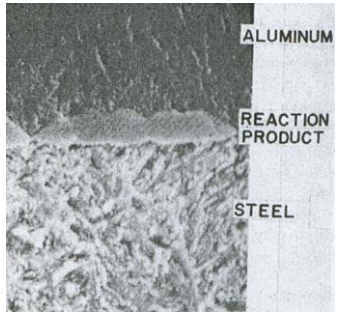
Objectives:

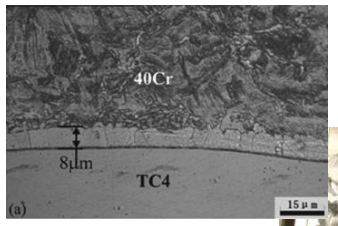
- Create structural joints between steel and alternately aluminum or titanium
- Define processing conditions circumventing metallurgical compatibility challenges
- Provide interpretation of bonding mechanisms

Key Project Stakeholders

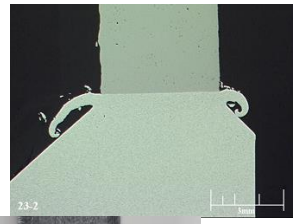
- EWI
- MTI
- LIFT
- Boeing
- Tenneco
- Lockheed Martin

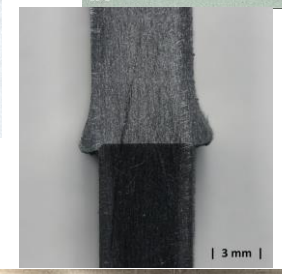
Metallurgical Challenges



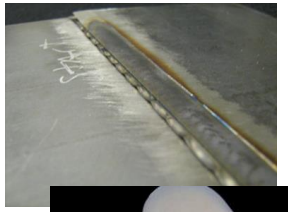


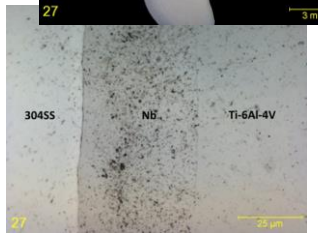
Friction Processing





Resistance Processing





Joining of Aluminum Alloys to Steel

- Suppression of intermetallic compounds
- Rapid thermal cycles
- Low peak temperatures
- Example technologies
  - Inertia welding
  - Linear friction welding
  - Friction stir welding
  - Low force friction welding

Joining of Titanium Alloys to Steel

- Prevention of eutectic formation and intermetallic compounds
- Use of refractory metal interlayer technology
- Simple strain paths
- Example technologies
  - RMSeW
  - UW

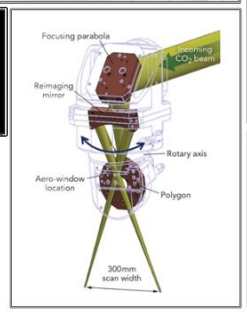
EWI Laser Welding Overview

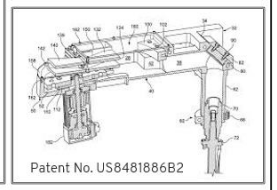
Laser Coating Removal

- The USAF and others have sought successful solutions for coating removal for decades.
- Ineffective, power-limited laser beam scanning devices were weak links leading to EWI's IR&D work to invent, demonstrate, patent, and license a new laser beam scanner.
- EWI's scanner now holds every **world record** for laser paint stripping **efficiency** and **productivity**.
- Commercialization Applications
  - Boeing: Cleaning SPF dies
  - LR Systems: De-painting commercial Aircraft

LR Systems

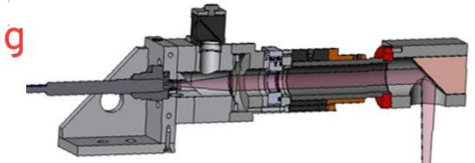
SwRI Demo

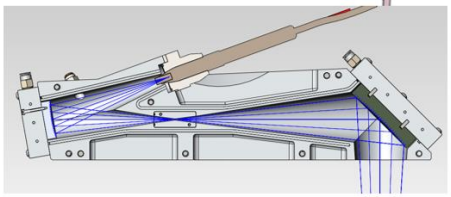


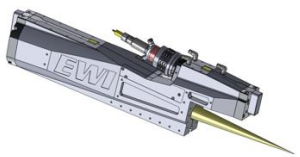


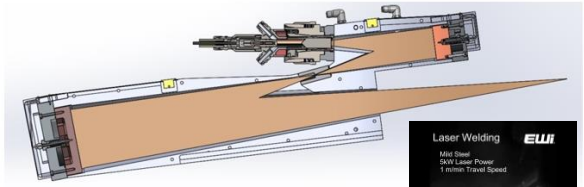
High-Power Optics Design/Welding

- Credible, robust, and affordable laser power levels have been increasing rapidly in the last decade.
- Available, robust, focusing optics for these higher power lasers have not kept pace.
- EWI conducted IRD work to invent and patent a focusing optic that works at very high power.
- Excellent weld quality & process confidence achieved.



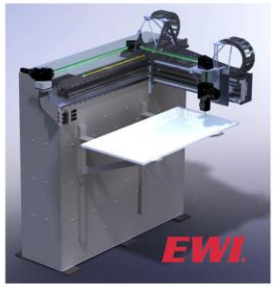


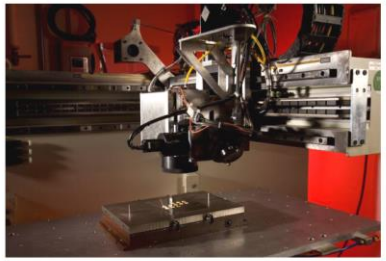


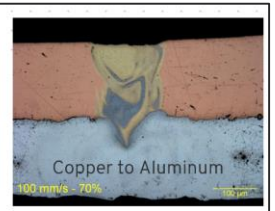


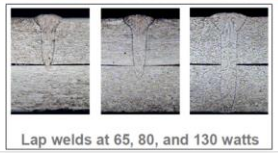
https://www.youtube.com/watch?v=CRMrdmWPKJc

High-Speed, Remote Welding & Cutting





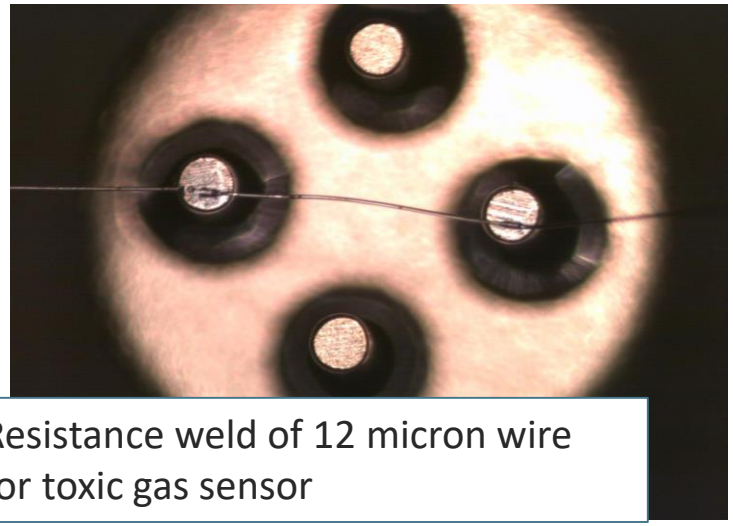




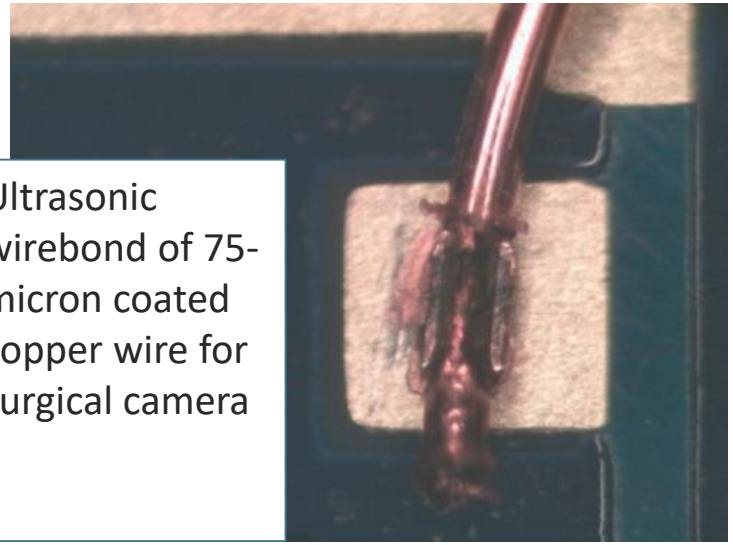
EWI
We Manufacture Innovation

EWI Microjoining & Ultrasonic Welding

- Capabilities for joining a wide range of materials and dissimilar-material combinations: metals to non-metals: polymers, glasses, ceramics, and metal-matrix and polymer composites
- Applications for electronics, sensors, batteries, detonators
- Resistance welding, parallel gap welding, wirebonding, ultrasonic metal welding, soldering.
- Material thicknesses <0.25 mm (~0.010 in.)
- Joint quality measured as joint strength, electrical conductivity, corrosion resistance, visual appearance, hermeticity.



Resistance weld of 12 micron wire for toxic gas sensor



Ultrasonic wirebond of 75-micron coated copper wire for surgical camera

Questions?

Next Steps?

Mark Schimming
VP Government Programs
mschimming@ewi.org

Dennis Harwig, PhD
EWI Senior Technical Leader
OSU Research Assoc Professor
dharwig@ewi.org
614-440-5124