ORNL Leads Major R&D Program

ORNL Mission
Deliver scientific discoveries and technical breakthroughs needed to realize solutions in energy and national security and provide economic benefit to the nation

- Energy Technologies
- Ultrascale Computing
- Biological Systems
- Advanced Materials
- Neutron Science
- Climate
- Nuclear Science
- National security
Polymer Composite Printing at ORNL

- Knowhow in 3D printing of polymer composites should be applicable to coatings by an automated robotic process.

Current Status:
- Fused Deposition Modeling
- Deposition of multiple polymers (foams, engineered material, composites)
- Pick and place of sensors

Vlastimil Kunc, kuncv@ornl.gov

ABS and ABS + Carbon Fiber

PLA to PLA Foam

www.ornl.gov/manufacturing
Coextrusion of Curable Prepolymers and a Long History of Polymer Composite Formulation

A national asset to assist industry in lowering carbon fiber cost, scaling technology, and developing products and markets


Reactive extrusion of polyurethane/urea precursors

Orlando Rios, rioso@ornl.gov

https://iacmi.org/

Amit Naskar, naskarak@ornl.gov
Driving the Next Materials Revolution
Creating a Framework for Coupling Data Analytics with Advanced Manufacturing

- Data analytics in advanced manufacturing are applicable for an automated robotic repair tool
Primer-less Self-healing Sealants/Adhesives

- Self-healable coating will provide longevity
- Coating without surface preparation needs to be carefully designed

Conventional Sealants

- Re-adhesion to substrates is not possible
- Cracks are permanent

ORNLS’s Self-healing Sealant

- Absorption of contaminants produces continuous adhesion
- Re-adheres to substrates with original adhesion strength
- Self-heals cracks

Diana Hun, hunde@ornl.gov, Tomonori Saito, saitot@ornl.gov
Fast Curing Epoxy and Control Parameters for Adhesion

- Minimal curing and robust coating formulation will be needed

Self-healing Barrier Film for Vacuum Insulation Panel

Epoxy cures within 20s

The importance of balancing catechol groups and degree of crosslinking was identified


DOE EERE BTO

Rational Design of a Multifunctional Binder for High-Capacity Silicon-Based Anodes

Grafting of Adhesion Groups

Degree of Crosslinking Density

Low

Softer

Optimal Binder Performance

Low

High

Stiffer

High

ACS Energy Lett. 2019, 4, 1171−1180

DOE EERE VTO

Tomonori Saito, saitot@ornl.gov
Next Generation Self-Sensing Multifunctional Composites via Embedded Nanomaterials

- Self-sensing composites could be used to detect failures in pipes

Out-of-plane through thickness variation of composite resistivity was monitored during dynamic mechanical forces

Method to integrate ceramic nanoparticles into composites

Amit Naskar, naskarak@ornl.gov
Chris Bowland, bowlandcc@ornl.gov

Laser Induced Fluorescence-Based Nondestructive Evaluation of Heat Damaged Composite Aircraft

- Laser Induced Fluorescence can detect defects

After paint removal, operator inspects fire damaged area to assess extent of exposure; area size determines repair or part replacement

2008 R&D100 Award

- Carbon fiber /epoxy based composite structures experience delaminations, disbonds, cracking and surface blistering at temperatures beyond 550°F
- Acoustic based NDE techniques can detect these types of damage
- Heat damaged polymer matrices exhibit changes to their laser induced fluorescence spectra over a range of time/temperature expose conditions including those defined as incipient damage

Christopher Janke, jankecj@ornl.gov
Infrared Nondestructive Weld Examination System

- Infrared and Acoustic nondestructive inspection tools used for welding can be used for pipes
- Technology
  - Capable for both real-time online and post-weld NDE
  - Suitable to high-volume mass production environment
- 2015 R&D100 Award

On-going: Real time control of welding process based on AI and machine learning

DOE EERE Vehicle Technology Office, in collaboration with auto and steel industry

DOE NE

Zhili Feng, fengz@ornl.gov
Conclusions and Outlook

• Many technologies in advanced manufacturing coupled with data analytics are applicable for automated robotic repair tool

• Advanced composite coating with no surface preparation, minimal curing time, robust mechanical properties and tailored processability along with self-healing and self-healing is possible

• Inspection tool with data analytics (machine learning etc.) developed for other technologies including inspecting welding (Infrared, acoustic) and composite (laser) is applicable for the development for the inspection tool in REPAIR

Thank you for your attention!

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