

an industrial perspective on Manufacturing USA Institutes
fostering industry-university-federal laboratory
collaboration through IACMI

National Academies Innovation Policy Forum
Washington DC
November 14, 2018



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outline

an introduction to Ashland and IACMI

why did Ashland get involved in IACMI?

how has Ashland been involved in IACMI?

what benefits has Ashland received from our involvement?

next steps

take-home message

- o the IACMI consortium has been a very effective way for industry, universities and the federal labs to collaborate on industrially-relevant technology

an overview of Ashland

- o a global leader in specialty chemical solutions for industrial & consumer markets
 - o total sales in 2018 were \$3.7B
- o over the past decade, Ashland has transformed itself from an oil company into a global, diversified specialty chemical company
 - o strengthened by three key acquisitions
 - o Hercules in '08, International Specialty Products (ISP) in '11, and Pharmachem in '16



- o three business units:

Specialty Ingredients



Composites



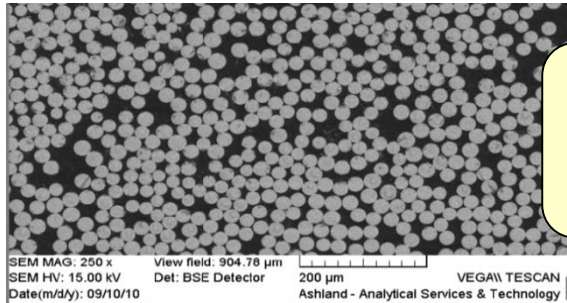
I represent
Ashland Composites
HQ = Dublin, OH

Intermediates & Solvents



Ashland Composites

- o business-to-business focus
- o revenue = \$750MM
- o major product lines
 - o **resins for composites**



Microstructure of a fiber-reinforced polymer matrix composite:

Light phase = glass fibers
Dark phase = resin matrix

- o composite resins are based on **thermoset** resin chemistry
 - o unsaturated polyesters (UPRs)
 - o vinyl esters (VERs)
 - o glass fiber is the most common reinforcement
- o **material substitution & material enhancement**
 - o replace / enhance metals, wood & concrete with composites



composites made with Ashland resins

key markets

- o transportation
- o building & construction
- o infrastructure
- o industrial / corrosion
- o marine



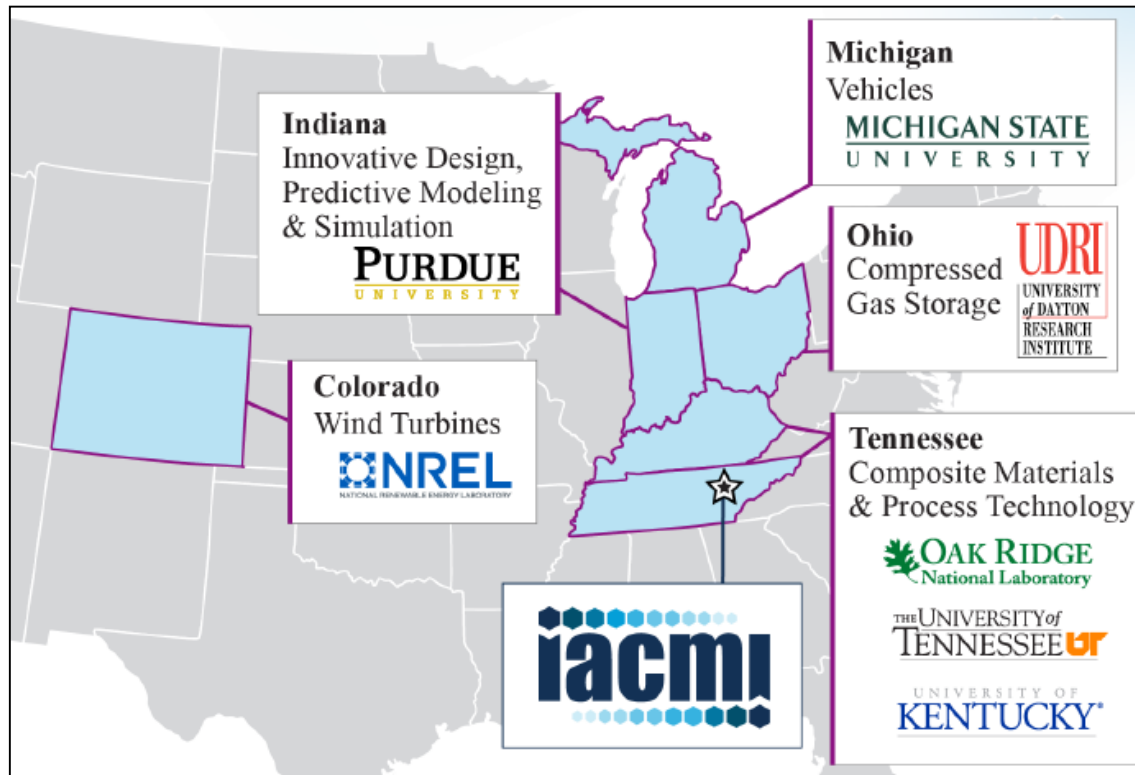
what is IACMI?

- o IACMI = Institute for Advanced Composites Manufacturing Innovation
- o a Manufacturing USA institute started in 2015
 - o 5-year, \$70MM DOE-funded institute
 - o \$180MM additional investment from states and industrial partners



an overview of IACMI

- o public-private partnership = Industry + Academia + Federal Labs
- o 7 centers: 2 Federal labs = Oak Ridge Nat'l Lab, National Renewable Energy Lab (NREL)
5 Universities = Purdue, Michigan State, Tennessee, Kentucky & the University of Dayton Research Institute (UDRI)



www.iacmi.org

IACMI's mission

- o drive adoption of advanced composites = **carbon fiber composites**
- o stronger, stiffer, lighter



- o Ashland's resins have historically been used with glass fibers, not carbon

IACMI's goals and focus areas



CENTERS OF EXCELLENCE

MICHIGAN	OHIO	COLORADO with NREL	INDIANA	TENNESSEE With ORNL
Automotive Manufacturing	Compressed Gas Storage	Wind Energy Manufacturing	Manufacturing Simulation	Materials Development
Joining	Automotive Manufacturing	Wind Energy Simulation	Recycling/ Product Life Cycle Management	Advanced Characterization
	Wind Energy Manufacturing	Wind Energy Testing	Recycling	Non-Destructive Evaluation

why did Ashland get involved in IACMI?

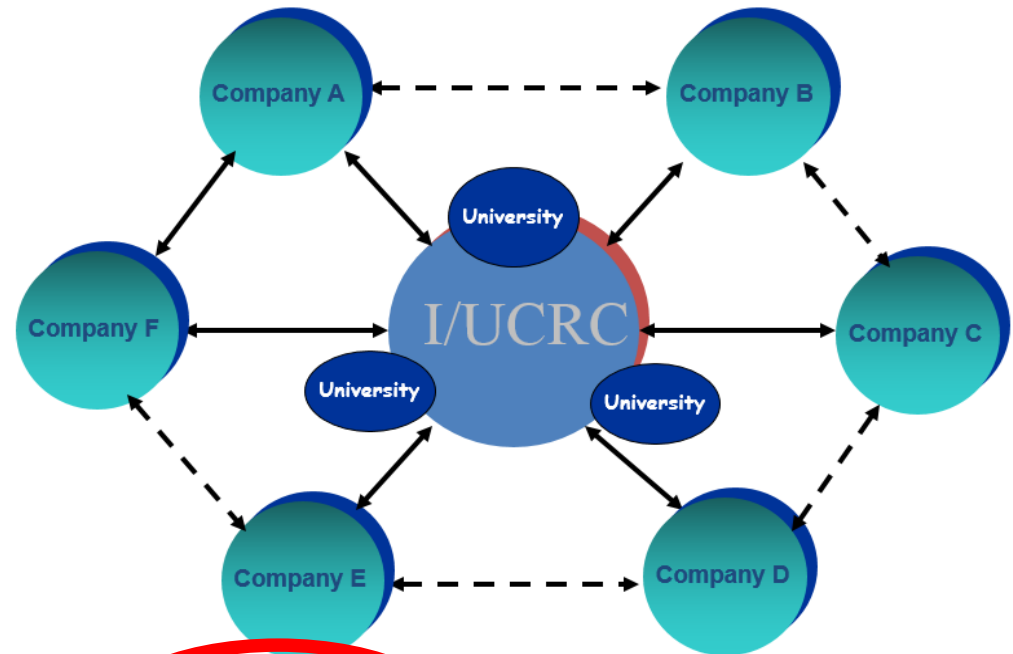
my external technology role at Ashland

- o connect Ashland with other companies, universities, federal laboratories and other organizations that have already developed technology / products that we can use.
- o motivation:
 - o accelerate the development of new products, services & applications
 - o spur innovation
 - o supplement our internal resources with external resources
- o approach: 
- o key elements of my external technology role:
 - o technology scouting
 - o **partnerships**

involvement in consortia

- o a key element of our collaboration strategy is **membership in consortia & centers**
 - o university ERCs and I/UCRCs
 - o IPRIME at U Minnesota
 - o CBiRC at Iowa State
 - o Manufacturing USA institutes

- o the I/UCRC Model:



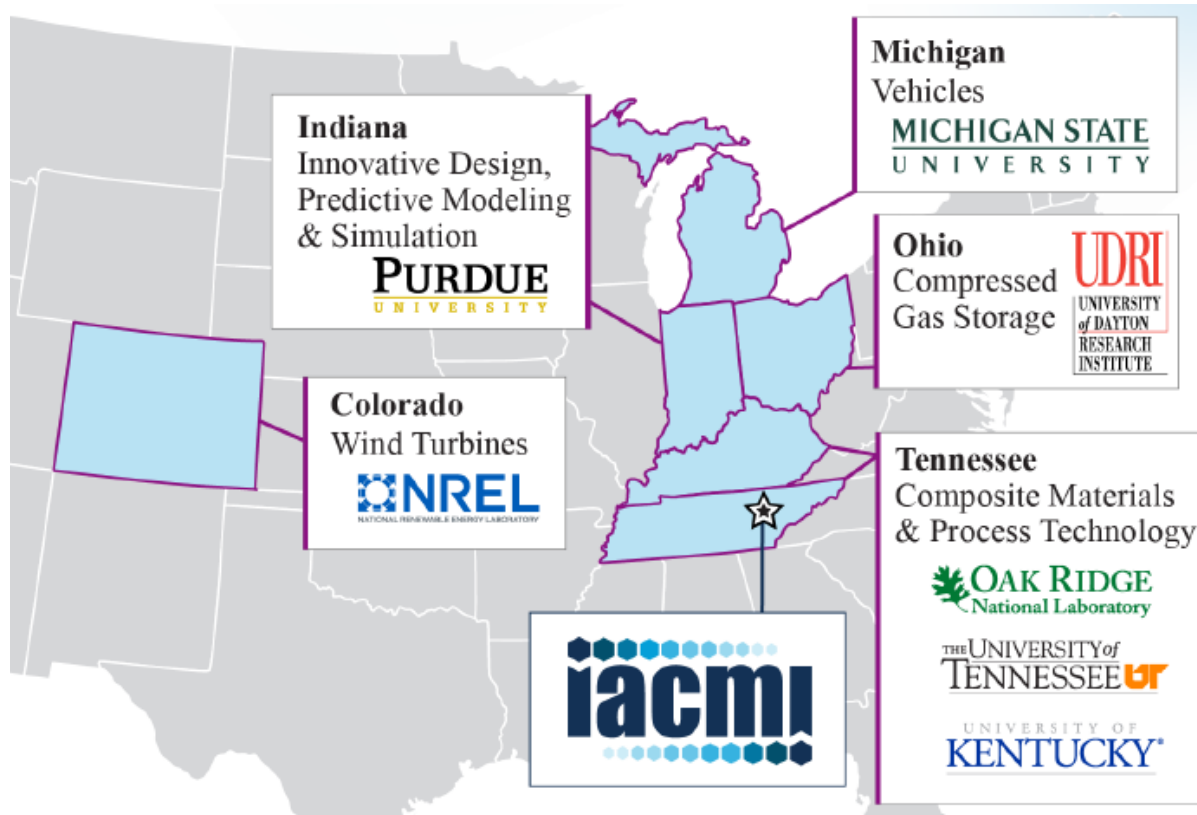
Multi-university increases the research base
Multiple companies provide interaction capabilities

- o motivation:
 - o access to technology
 - o networking / partnering opportunities
 - o exposure
 - o for Ashland
 - o to students
- 13 o cost-effective spend of our funding for external technology

Ashland's membership in consortia

Consortium	Acronym	Location	Overlap with APM
Advanced Structures & Composites Center	ASCC	Maine	Composites
Industrial Partnership for Research in Interfacial Mat'l's & Engineering	IPRIME	Minnesota	Polymers
Center for Biorenewable Chemicals	CBiRC	Iowa State, Rice, UC-Irvine, Wisconsin, Virginia	Bio-based chemicals
Ohio Bioproducts Innovation Center	OBIC	Ohio State	Bio-based chemicals
Center for Sustainable Polymers	CSP	Minnesota, Cornell, UC-Berkeley	Green Chemistry
Institute for Advanced Composites Manufacturing Innovation	IACMI	Michigan State, UDRI, Purdue, ORNL, NREL	Advanced Composites

access to technology

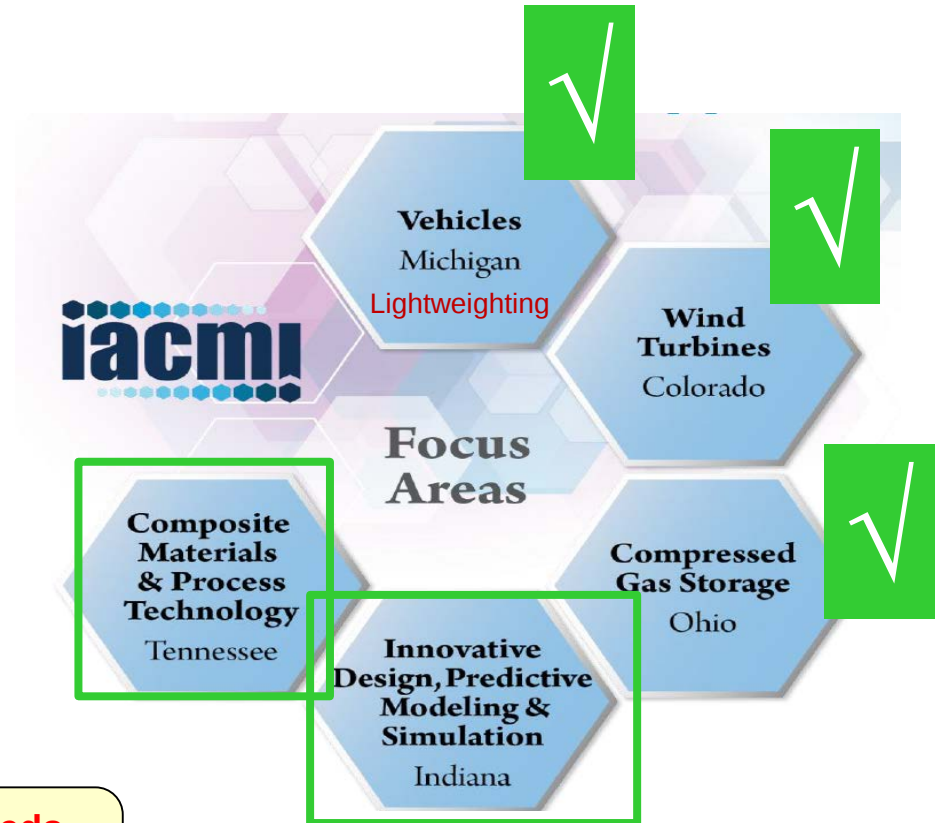


**IACMI provides access to
technology and expertise
at multiple centers**

overlap of Ashland's interests with IACMI

CENTERS OF EXCELLENCE

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**very good overlap with Ashland's needs
for Advanced Composites technology
(carbon fiber composites)**

networking / partnership opportunities



IACMI provides access to multiple potential partners throughout the composites value chain.

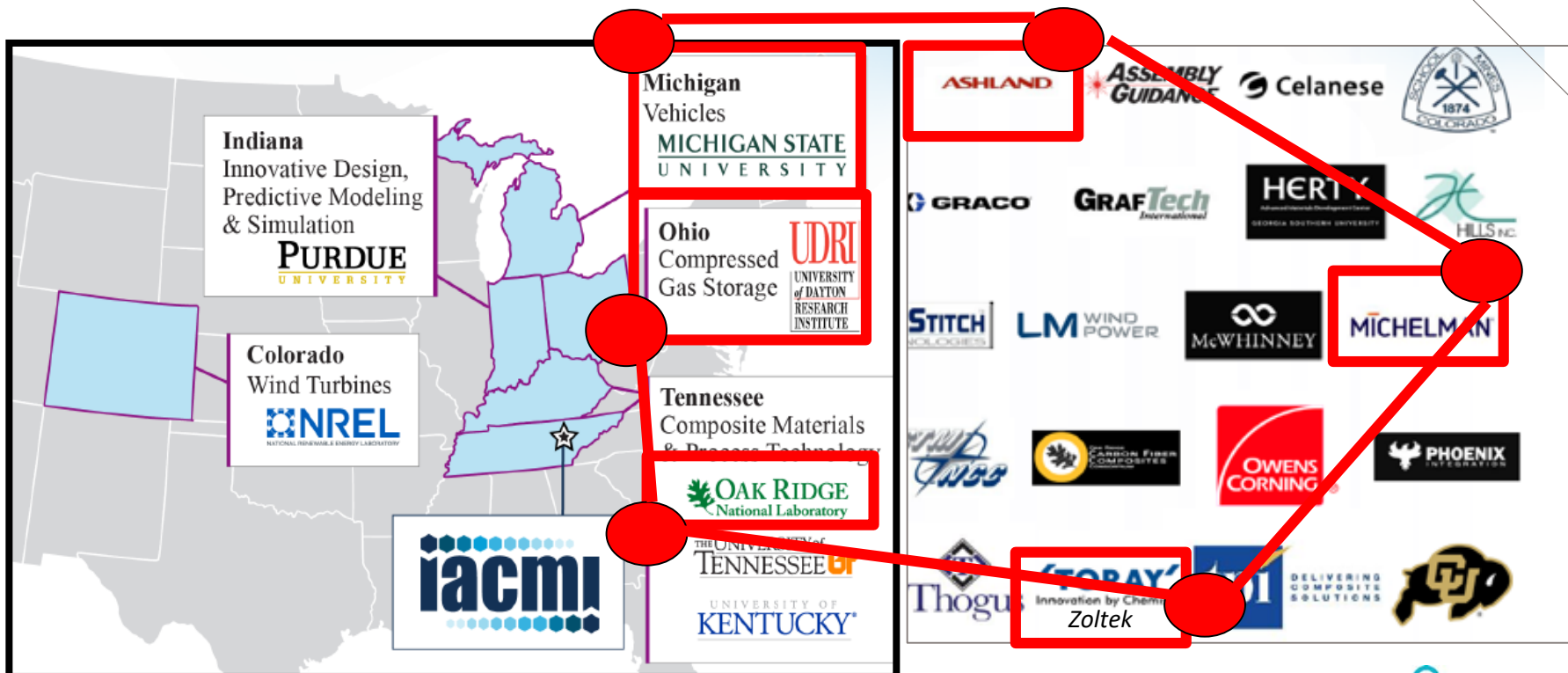
There are currently 160+ members listed on the website.



how has Ashland been involved in IACMI?

connecting the dots within IACMI

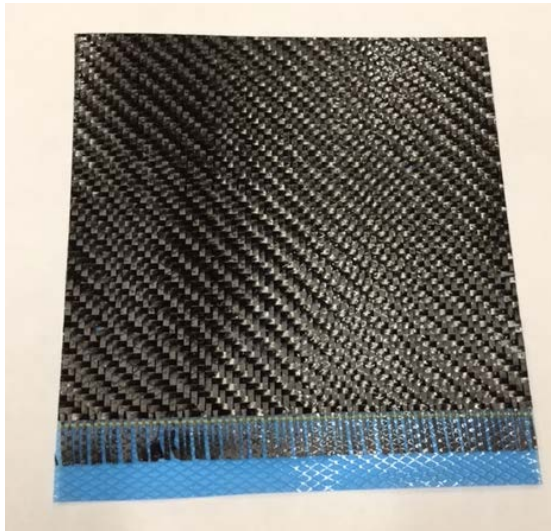
- o we led a project to develop resin & sizing technology for **vinyl ester/C fiber composites**
- o the project involved 3 IACMI centers & 3 industrial partners
- o the project lasted from Feb '17 to Jan '18



an overview of our IACMI project

- o project title: **optimized resins & sizings for vinyl ester/carbon fiber composites**

“Prepregs to Parts”



vinyl ester / C fiber prepreg



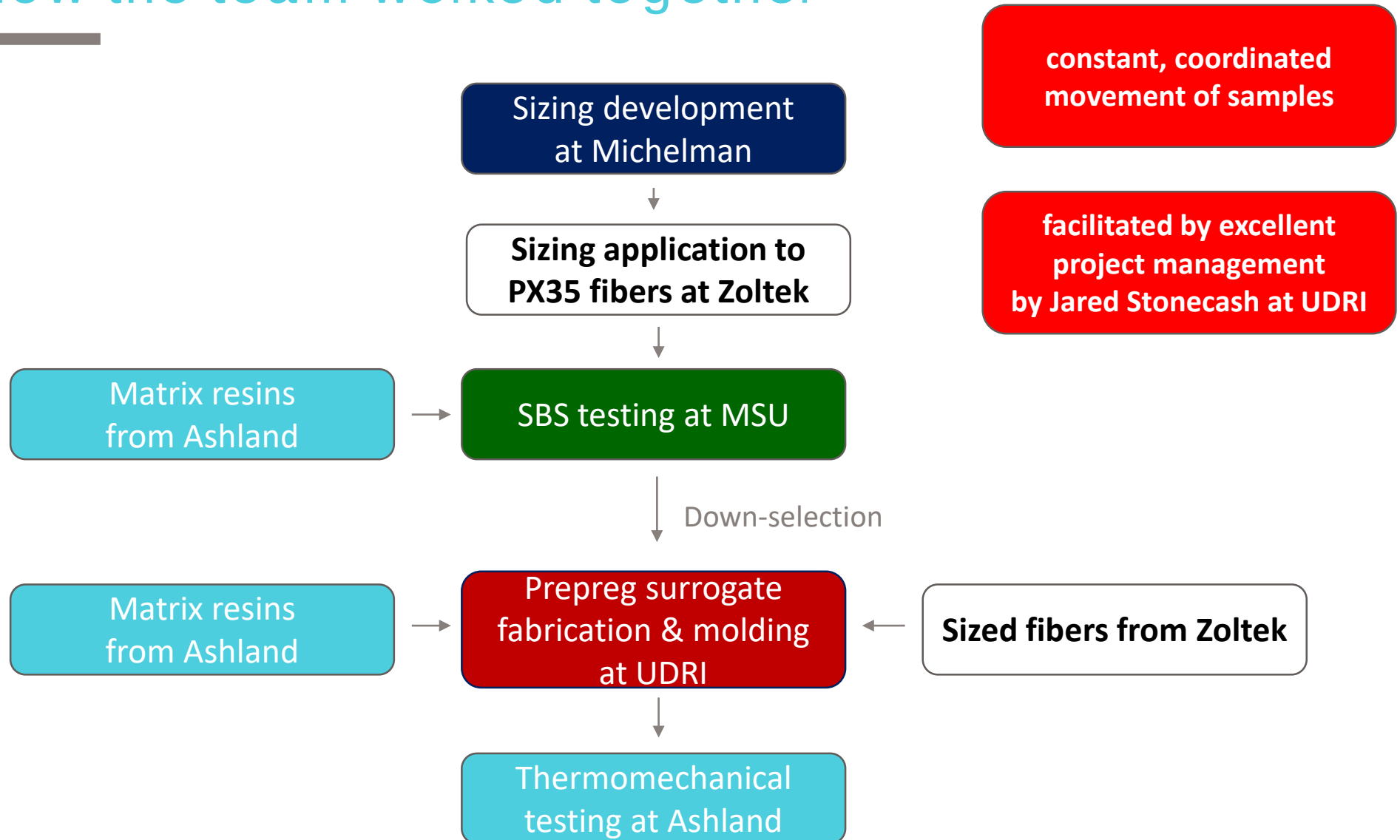
compression-molded hood

- o **industrial relevance !!!**
 - o carbon fibers
 - o fast production speed
 - o recyclable waste

our IACMI project team

partner	responsibilities
	Resin Development, Mechanical & Thermal Analysis Testing
	Sizing Development
	Sizing Application to Carbon Fiber
	Characterization of Resin-Fiber Interface
	Fabrication & Molding of Prepreg Surrogates, Project Management
	Embodied Energy Model, Benchmarking Data, Cost Modeling
	

how the team worked together



what benefits has Ashland received
from our involvement in IACMI?

technology benefits

a vinyl ester / carbon fiber prepreg system with:

- o no styrene
- o long shelf life (> 25 months)
- o no need for refrigeration
- o fast cure (≤ 3 minutes)
- o improved resin-fiber interface and mechanical properties
- o reduction in the amount of process scrap that needs to go to a landfill
- o reduction in embodied energy
- o cost-effectiveness

we demonstrated that an optimized resin/sizing/fiber system using vinyl ester resins & carbon fibers had advantages in....

- processing**
- molding**
- recycling & re-use**
- relative to epoxy/carbon systems**

other benefits of involvement in IACMI & IACMI projects

o new opportunities

- o automotive and non-automotive opportunities for prepregs
 - o with carbon and with glass
- o Ashland has been pulled into two other IACMI projects
- o three additional projects are going through the approval process

o connections

- o IACMI connected Ashland to Michelman and Zoltek
- o recycling and modeling connections

o leverage

- o access to existing equipment and expertise
- o access to interns
- o access to \$ from the DOE, the state of Ohio, and our industrial partners

IACMI-The Composites Institute Announces Project to Optimize Resins and Sizings for Vinyl Ester / Carbon Fiber Composites

Knoxville, TN, March 9, 2017... The Institute for Advanced Composites Manufacturing Innovation, IACMI, a Manufacturing USA institute driven by the University of Tennessee, Knoxville and the U.S. Department of Energy, in partnership with Ashland, Zoltek, Michelman, University of Dayton Research Institute (UDRI), JobsOhio, and Michigan State University (MSU) announces a project focused on the optimization of vinyl ester resins and fiber sizings for the fabrication of carbon fiber composites. The effort will identify styrene-free prepreg formulations with longer room temperature shelf life, shorter cycle times, and reduced cost. Advancements in these areas will increase productivity, decrease scrap and material costs, and enable adoption into the automotive industry.

IACMI-The
Composites
Institute
Announces
Project to
Optimize
Resins and
Sizings for



optimized resins & sizings for vinyl ester / carbon fiber composites

IACMI PA 16-0349-5.3-01

IACMI semi-annual review
Detroit, MI
January 16, 2018

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presentations, posters & videos

Optimized Resins and Sizings for Vinyl Ester/ Carbon Fiber Composites
Andy Munro (B.C.E.), University of Dayton Research Institute
Mentor: Mike Pratt, University of Dayton Research Institute

Background / Objectives

- Currently, carbon fiber composites are used to a very limited extent in automotive applications. There is a clear need for cost-effective technology that will enable the use of composites to become more widespread in the automotive industry.
- With this issue, our goal is to identify and develop novel vinyl ester resin / fiber sizing / carbon fiber combinations that will provide a strong interface that improves mechanical performance, enable fabrication of lightweight composites suitable for automotive applications, and cost-effective.

Materials and Methods

The Project Team:

Ashland	Resin Development, Mechanical Testing
MICHELMAN	Sizing Development
ZOLTEK	Sizing application to PX35 Fibers
MICHIGAN STATE UNIVERSITY	Characterization of Resin-Fiber Interface
UDRI	Fabrication & Molding of Prepreg Surrogates & Project Management

- Spools of different sized carbon fibers were sent to UDRI from Zoltek and Michelman.
- These spools were dry filament wound around a mandrel, where a 13"x 13" resin film was then applied to the fiber. The fiber and films were cut off the mandrel and trimmed down to 12" x 12" plies.
- Process repeated until 16 plies were made and ready to be "wet out" within a vacuum bag inside an oven.
- The plies were then stacked on to one another and ready to be compression molded into one consolidated panel.
- Once cured, the carbon fiber panel is ready to be tested for mechanical properties.

Results of panel quality and mechanical properties to come...



next steps

next steps

- o IACMI 1.0
- o IACMI 2.0

next steps: IACMI 1.0

- o continue to be involved in ongoing IACMI projects
 1. composite liftgate for Volkswagen
 2. recycling technology for end-of-life composite waste

- o get involved in IACMI projects in the pipeline
 1. vinyl esters for Long Fiber Injection (LFI)
 2. carbon fiber Sheet Molding Compound (SMC)
 3. co-molding of prepreg with SMC

**new business
opportunities !!!**

next steps

- o there has been enormous investment by IACMI in facilities during the past 3 years



"Corktown" = IACMI Scale-up Research Facility (SURF) in Detroit



wind blade prototype production facility at NREL



modeling, simulation & validation center at Purdue

- o we need to continue to leverage these facilities beyond Year 5 !!!

next steps: IACMI 2.0

- o advocate for “IACMI 2.0”



- o add **infrastructure** to the list of focus areas for IACMI 2.0
 - o there is a tremendous need in our nation
 - o bridges, water infrastructure, disaster-resistant infrastructure.....
 - o composites are an excellent fit for infrastructure replacement & repair

composites & infrastructure

- o composites are an excellent fit for infrastructure replacement & repair
- o lightweight – easy to transport and install
- o corrosion-resistant
 - o composite rebar & arches for bridges
 - o pipes
 - o seawalls
- o durable, resilient
 - o disaster-resistant infrastructure
 - o utility poles



momentum on the infrastructure front

- o the American Composites Manufacturer's Association (ACMA) is having considerable success in its efforts to advocate for composites on Capitol Hill

Friday, August 24, 2018 RSS Email

Congress Introduces Comprehensive Legislation to Advance Study and Deployment of Composites in Infrastructure

The American Composites Manufacturers Association (ACMA) announces the introduction of the **IMAGINE Act** into Congress promoting the use of innovative materials, like composites, to modernize our nation's infrastructure.

Congressional Committee Approves the NIST Reauthorization Act of 2018

by Evan Milberg | July 2, 2018

Last week, U.S. House Science, Space, and Technology Committee unanimously approved the **National Institute of Standards and Technology Reauthorization Act of 2018**. The bill includes a provision directing \$11 million to undertake the standards development work recommended in the report from a NIST/ACMA sponsored workshop **addressing barriers to increased adoption of composites** in infrastructure.

making Infrastructure
part of IACMI 2.0 will
keep this momentum going

in summary

- o the IACMI consortium has been a very effective way for industry, universities and the federal labs to collaborate on industrially-relevant technology
- o benefits
 - o access to technology at multiple federal laboratories and universities
 - o networking / partnering opportunities throughout the composites value chain
 - o exposure within the Advanced Composites community
 - o new business opportunities
 - o leveraged funding & resources
- o Ashland plans to continue our involvement in IACMI 1.0 and we will advocate for “IACMI 2.0”
 - o include Infrastructure !!!



*thank you
for your attention
questions ??*

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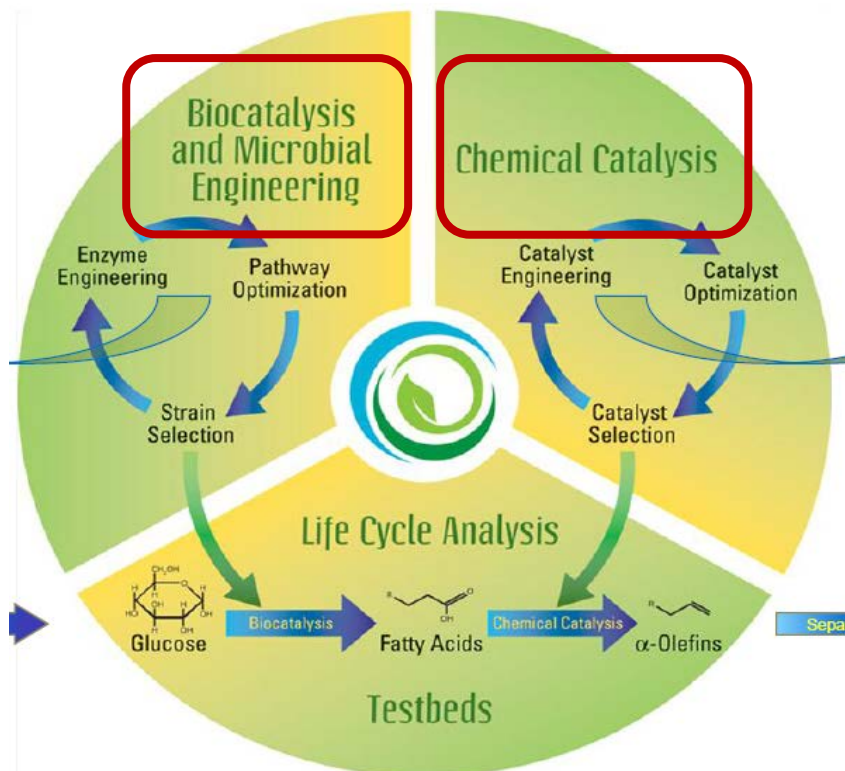


IACMI internships



Center for Biorenewable Chemicals (CBiRC)

- o Engineering Research Center (ERC) at Iowa State
- o researchers at Iowa State, Rice, Wisconsin, Virginia, UC-Irvine
- o over 30 industrial members



**CBiRC helped us gain
a much better understanding
of fermentation**

networking benefits of CBiRC

- o CBiRC membership spans the entire value chain for bio-based chemicals

