Carbon Fiber Technology Facility

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Project ID: CPS# 25349

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Overview

Timeline

- Capital project completed March 2013 (ARRA funded)
- Operations from March 2013 to present

Budget

	FY 2015	FY 2016	FY 2017	FY 2018
Total Budget	5.5 M	5.3 M	6 M	6 M
VTO commitment	1.5 M	1.3 M	1.0 M	1.0 M
AMO commitment	4.0 M	4.0 M	4.0 M	4.0 M
Other commitment			1.0 M	1.0 M

Barriers addressed

- Cost of carbon fiber manufacturing
- Technology scaling
- Process Validation
- Workforce development

Partners and Collaborators

- Institute for Advanced Composite Manufacturing Innovation (IACMI)
  - 150 Members, 30 states
- Technical Collaboration Projects & CRADA's
  - More than 26 active projects underway and 12 pending
  - three Cooperative Research and Development Agreements (CRADAs)

Project Objective

The Carbon Fiber Technology Facility (CFTF) serves as a national resource to assist industry in overcoming the barriers of carbon fiber cost, technology scaling, and product and process validation. CFTF is intended to be the bridge from R&D to deployment and commercialization of low-cost carbon fiber

Focused on demonstrating the scalability of low-cost carbon fiber

- 42,000 ft^2 facility with production capacity of 25 tons/year of fiber from multiple precursors in various forms

Vehicle Lightweighting	Wind Energy	Gas Storage	Recreational Equipment
Reduce vehicle weight by using carbon fiber throughout body and chassis	Build turbine components and longer blade designs for applications in wind energy	High-strength, lightweight pressure vessels for storage of gas	Next-level performance for sporting goods and recreational equipment
			

Project Objective

Core Research and Development

Leveraging ORNL's Science Capabilities to Solve Challenges in carbon fiber and composites manufacturing.

Industry Collaborations

Cooperative research to develop and demonstrate low cost CF manufacturing to reduce the cost promoting and expanding the use of CF and its composites in clean energy applications

Education and Training

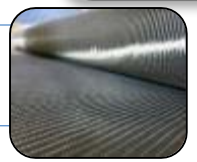
Internships, academic collaborations, workshops, training programs, and course curriculum for universities and community colleges.

The Carbon Fiber Technology Facility

1. Establish and perform collaborative R&D projects to reduce technical uncertainties in CF manufacturing process

2. Investigate potential alternative carbon fiber precursors

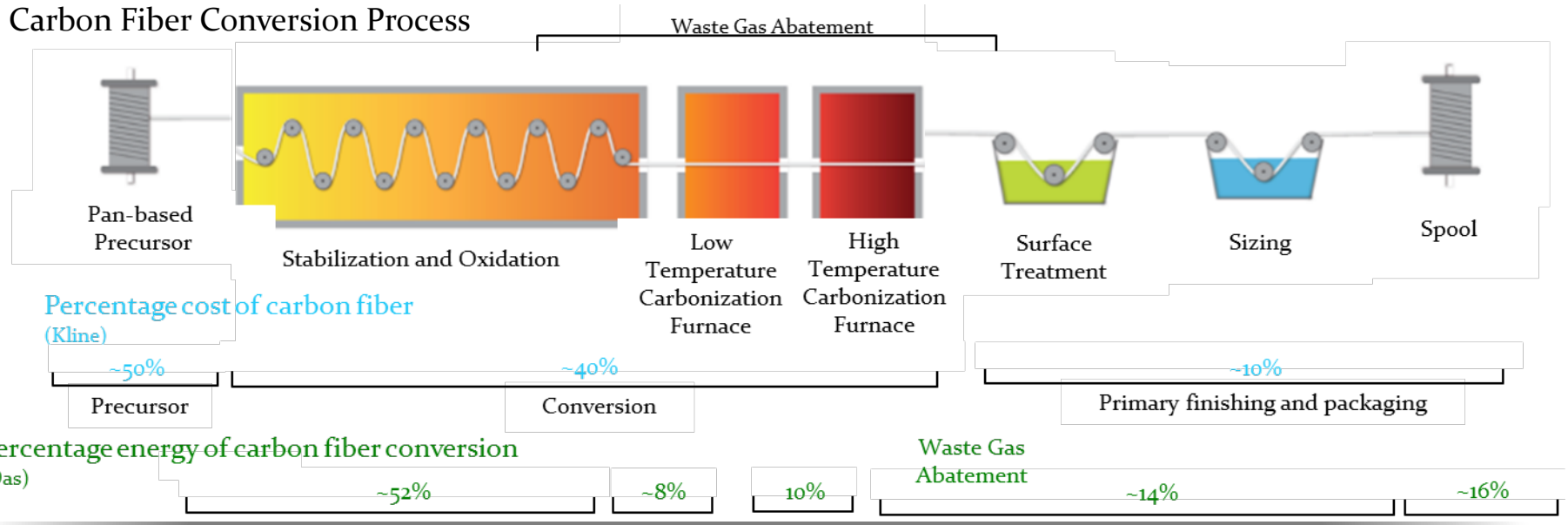
3. Investigate carbon fiber intermediate forms and technical challenges in composite applications



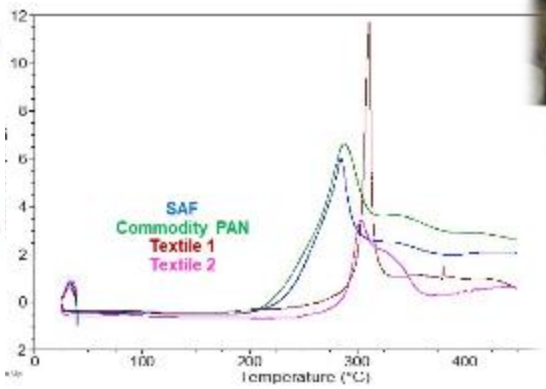
4. Establish artificial intelligence-based framework and correlate process data to product characteristics

5. Investigate and develop in process measurement, sensing and control methods

Technical Innovation



Intellectual property developed around scalable process for producing low cost carbon fiber. Differential scanning calorimetry (DSC) analysis of the precursors show potential difficulty in stabilizing textiles! ORNL team successfully overcame that deficiency during thermal oxidation of the precursor fibers.



Technical Approach

Material Identification

•Identify high potential, low cost alternative precursors

Scale-up CF Line

- Develop optimal mechanical properties of resultant carbon fiber from alternative precursors and correlate structure-property relationships.
- 25 ton/yr capacity, Instrumented research line
- Reduce Costs Drivers
- Process Science
- Increase Throughput
- Improve CF Properties
- Process simulations

Carbon Fiber Forms

Standard & Intermediate Modulus

•Provide sample quantities with favorable properties to industrial partners for testing based on ORNL approval

Collaborative Projects

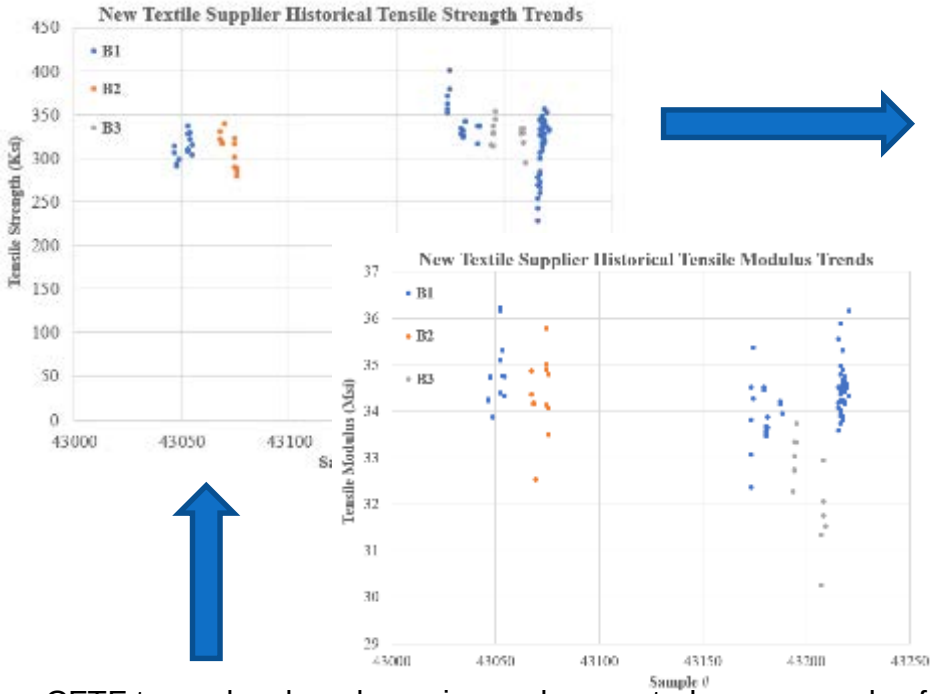
- Integrated approach to low-cost carbon fiber manufacturing R&D
- Individual R&D projects
- Collaborative R&D consortia
- Early-stage R&D and technology
- partnerships
- Industry Collaborations

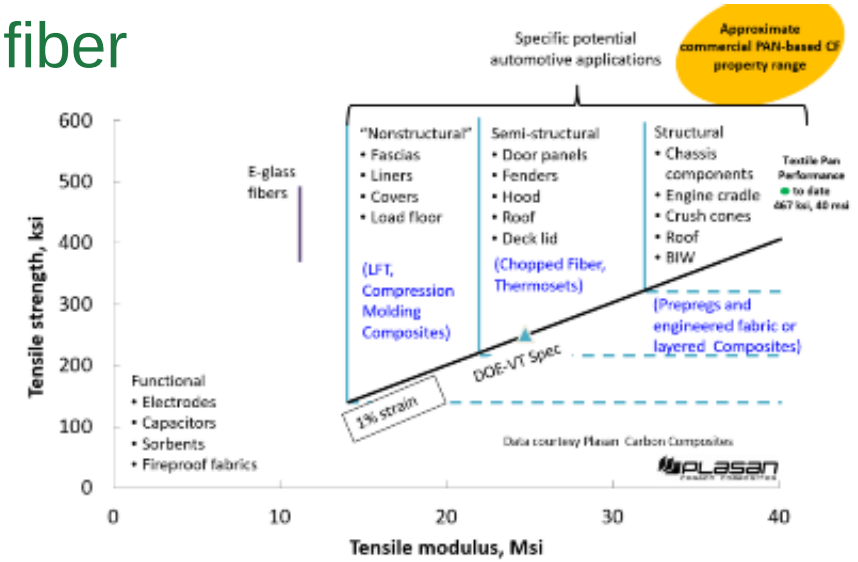
Ever Growing Partnerships: Integrating the AM Supply Chain

•Address feedback from industrial partners

Results and Accomplishments

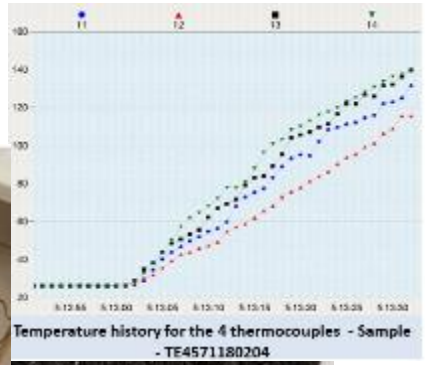
Performance of Low-cost Carbon fiber



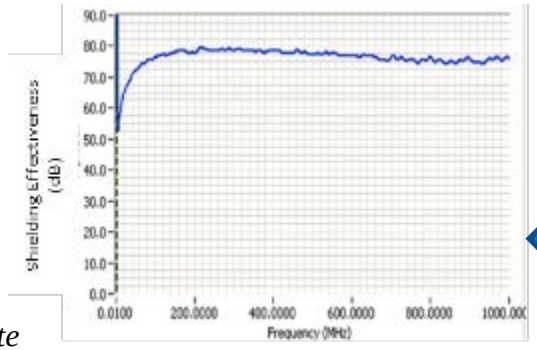


CFTF team developed a recipe and converted a new supply of textile-based precursor in 24 hrs.
Successfully converted > 15 varieties with favorable properties

Flammability Studies of oxidized fiber



Measurement of shielding effectiveness of a sample



0.131 mm carbon/epoxy plate

Results and Accomplishments

FIRST TIME EVER - Injection molding of Low-Cost Carbon Fiber and PA66

Objective	• First ever successful compounding and injection molding of a full size automotive component with PA66 and low-cost carbon fiber (LCCF) made from textile-grade PAN precursor
Approach	• ORNL manufactured the carbon fiber at the Carbon Fiber Technology Facility (CFTF) • Techmer compounded PA66 with 10% LCCF • Michigan State University (MSU) injection molded 15 fenders at IACMI's Scale-Up Research Facility (SURF)
Significance	• This achievement marks the first time a full part has been molded with ORNL textile PAN LCCF.
Next Steps	• Fenders will be injection molded with 40% LCCF/PA66 • Fenders will be injection molded with 50:50 blend of the 10% and 40% LCCF/PA66 to yield a 25% final loading

Fenders

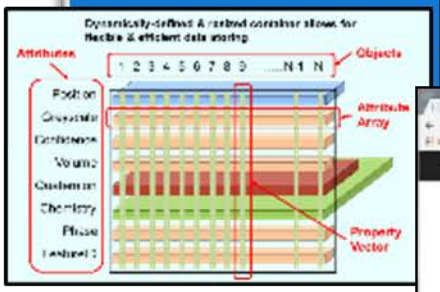
OAK RIDGE National Laboratory | TECHMER PM POLYMER MODIFIERS | The Institute for iacmi

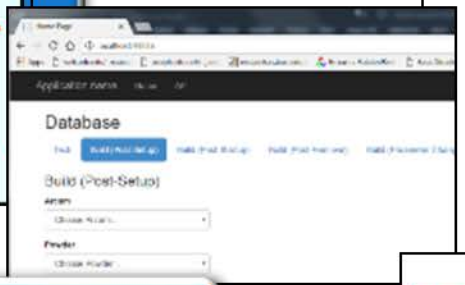
Developed low-cost carbon fiber at Carbon Fiber Technology Facility → Compounded 10% LCCF pellets with PA66 → Injection molded parts at Michigan scale-up facility, SURF

Results and Accomplishments

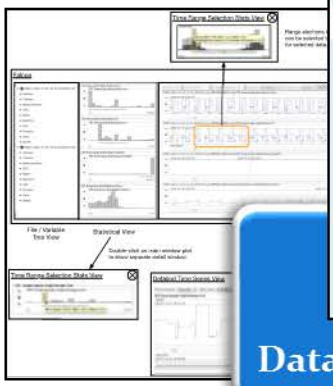
Data Analytics Framework for Manufacturing CFTF Modules

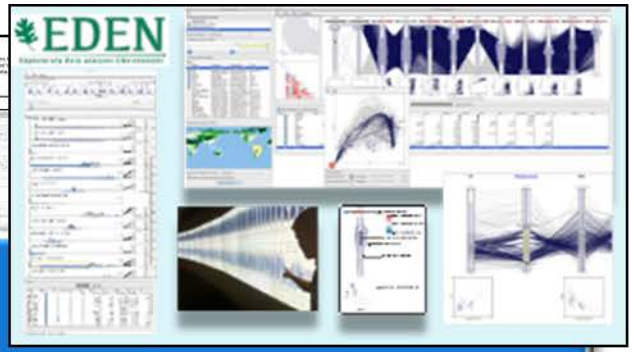
Data Management & Tracking



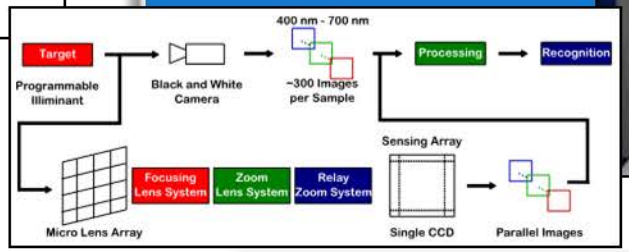


Data Visualization



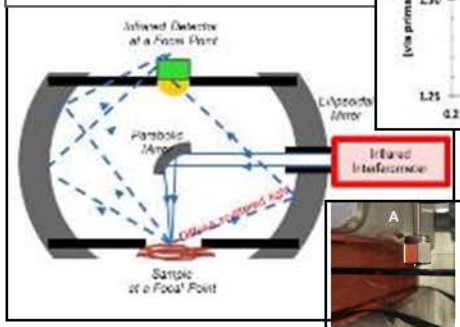


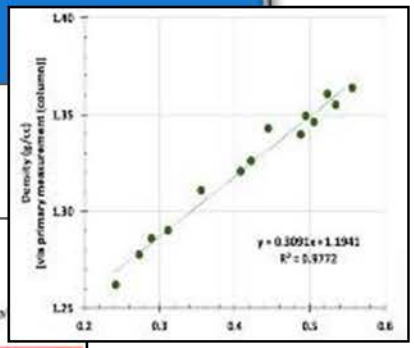
Computer Vision / Quality Control



Sensing

Investigate and develop in-process measurement, sensing and control Methods



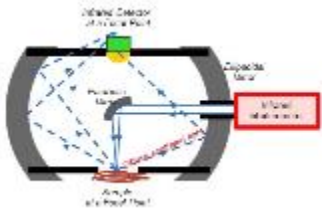


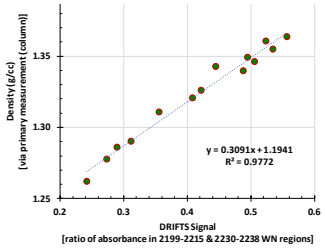
Machine Learning / Statistical Analysis

Results and Accomplishments

Sensing - Online Measuring Concepts

DRIFTS

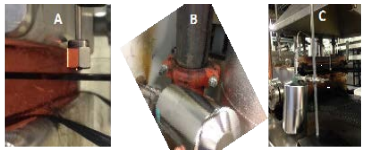


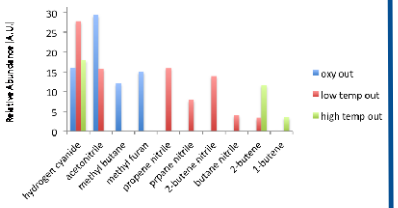


The Fourier Transform Infrared (FTIR) spectroscopy techniques will enable measurement of the specific fiber chemistry associated with crosslinking and cyclization reactions characterizing the chemical bonds present in the fiber material

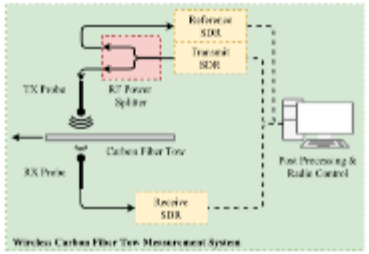
OFF-GAS Measurements

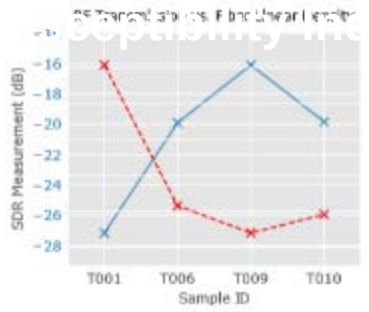
Off-gas measurements Extractive samples will be analyzed via standard methods including MS, FTIR and GCMS to identify the control species, which in process-control applications can be monitored via the real-time analytical techniques or other in-situ sensors.





CF Resistivity





This work explores the use of software defined radios (SDR) as a low-cost method to wirelessly probe the carbon fiber tow to determine material properties of the tow

*Magnetic Susceptibility Inductance

Relationship between degree of oxidation and crosslinking is expected to be observable through magnetic susceptibility measurement. Value of magnetic susceptibility of fiber tow can be measured and compared with a strength-related set point

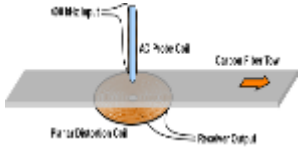
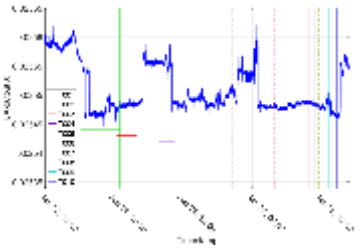
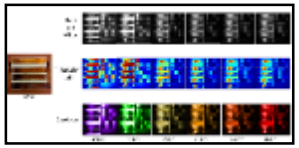
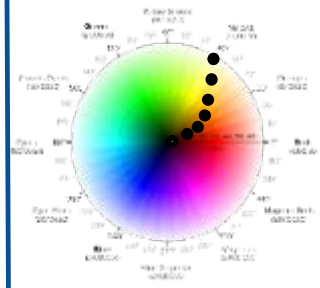


Illustration of component placement



Multispectral Imaging





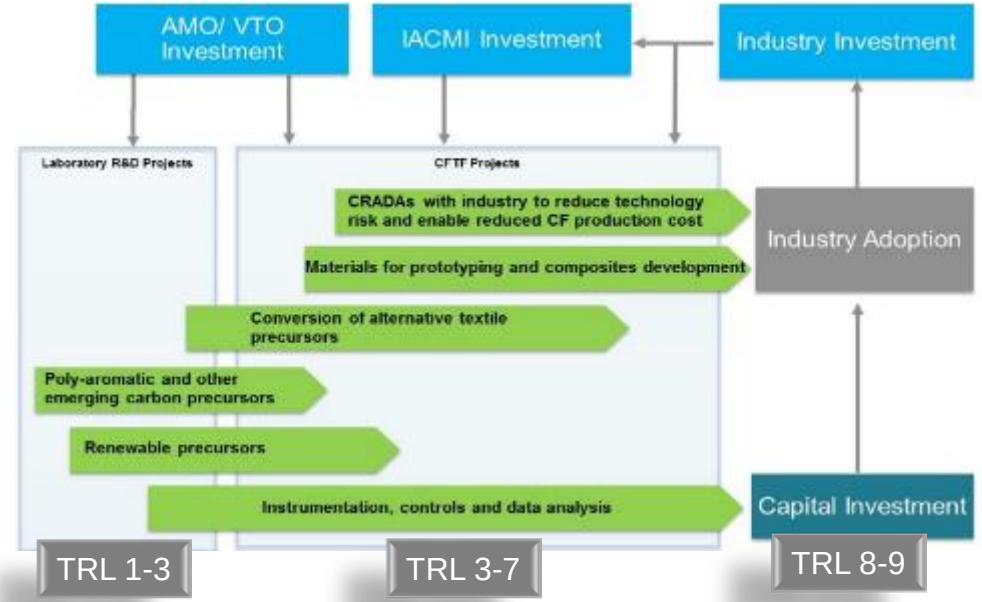
In-line and off-line multispectral measurements of the fibers, to capture the colorimetric information used by operators to estimate the quality of the fiber along the production line

*"Wireless Measurement of Carbon Fiber Tow Properties Using Software Defined Radio" - Publication ID 100515

Transition

Carbon Fiber Industry Collaboration

- *Over 50 Technical Collaborations*
- *FLC Technology Transfer Award*
- *New Material Suppliers*
- *4 Licensees for Textile precursor to CF*
- *11 CFTF Tech Interns to Licensee/UT-Battelle employees*
- *Three CRADAS*
- *Mission and Capabilities*
  - *Industry are able to adopt new opportunities using CF*
  - *Enhance their processes and capabilities, thus expand their market growth.*



December 2015 — **2 - Patents application**

Method of Producing Carbon Fibers from Multipurpose Commercial Fibers, (ORNL ID 3583), Pending U. S. Patent Application

June 2016 — **ORNL, License Selection**

US Job Creation
US Wealth Creation
Deployment of Clean Technologies
Company ability to develop and market a new product or service
Company's commitment to manufacture in the US

Aug. 2016 — **6 CFTF staff members hired by Licensee**

Aug. – Oct. 2016 — **ORNL, License #1 executed**

License #2 executed

December 2016 — **Technology Non-Provisional Patent application**

Method of Producing Carbon Fibers from Multipurpose Commercial Fibers, (ORNL ID 3583), Pending U. S. Patent Application

January 2017 — **ORNL, License #3 executed**

May 2017 — **3 CFTF Tech Interns transferred to UT-Battelle staff**

May 2017 — **1st CRADA Approval**

Company has an option to negotiate up to an exclusive license for patentable inventions created by ORNL staff under a CRADA

June 2017 — **ORNL, License #4 executed**

February 2018 — **Federal Laboratory Consortium Excellence in Technology Transfer Award**

Oct. 2017- Feb. 2018 — **2nd CRADA Approval**

3rd CRADA In progress

April –May 2018 — **3 Publications Submitted for Clearance**

QUESTIONS?


CARBON FIBER
TECHNOLOGY FACILITY
OAK RIDGE NATIONAL LABORATORY