VS176

Improved Tire Efficiency through Elastomeric Polymers Enhanced with Carbon-Based Nanostructured Materials

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OVERVIEW

Timeline	**Barriers***
• Project start date: January 2016 • Project end date: December 2017	• Development of technologies • Parallel paths (synergistic improvements) • Multiple technologies • Risk aversion • Cost-competitive options **from 2011-2015 VTP MYPP*
Budget (DOE share)	**Partners**
• DOE - $905k	• Oak Ridge National Laboratory • Industrial Partner

OBJECTIVE: To improve tire efficiency and meet DOE's fuel consumption reduction target of 4%, all while maintaining or improving wear characteristics of the tire

"WHY"

- In the United States motorized transportation is mainly implemented by road vehicles.
- The rolling resistance can be responsible for up to 25% of the energy required to drive at highway speeds*.

"HOW"

- To reduce the rolling resistance
- To replace existing fillers (such as carbon black and silica) with higher performance materials (viz., graphene and silica nanofibers)
- Reduce hysteretic losses
- Tailor the viscoelastic properties

*Reference: B.E. Lindemuth, ''An overview of tire technology'', Chapter 1 in ''The pneumatic tire'', U.S. Department of Transportation, National Highway Traffic Safety Administration, February 2006

RELEVANCE

- **Supports major goals of the Vehicle Technologies Program (VTP)**

Tires for Improved Fuel Efficiency

– Reduce the rolling resistance.

– Improve the fuel economy (mpg) of vehicles.

– A 25-30% reduction in the rolling resistance will result in improvement in fuel mileage of up to 4%*.

– Estimates for the California Energy Commission have indicated that about 1.5% to 4.5% of gasoline use could be saved if all replacement tires in the U.S. were low rolling resistance tires*.

– Improve the tear resistance.

- **Addresses the following Barriers:**

– **Development of technologies**: Design of new materials with tailored properties.

– **Parallel paths (synergistic improvements)**: Combines new materials with complementary properties.

– **Risk aversion**: Development of two types of filler material that will provide parallel improvements.

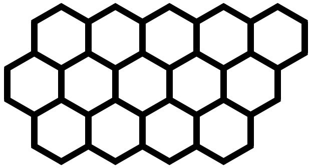
– **Cost-competitive options**: Enables fabrication techniques that can be scaled in manufacturing environment. Graphene filler material can potentially be fabricated easily and cheaply from bulk graphite.

***Reference: Vehicle Technologies Multi-Year Program Plan 2011-2015:**

http://www1.eere.energy.gov/vehiclesandfuels/pdfs/program/vt_mypp_2011-2015.pdf

APPROACH: Design of filler material

Graphene nanoplatelets



The highest:

Tensile strength

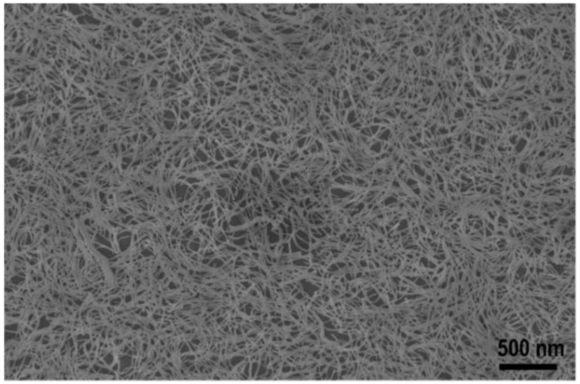
Young's modulus

Specific surface area

High thermal conductivity

+

Silica nanofibers



Nanoscale diameter ~100 nm

Flexible

Intrinsically low incidence of defects

High tensile strength

Tailoring the nanoscale properties associated with the physical characteristics of filler-filler and filler-elastomer interactions is an effective route for the design and fabrication of composite tires with unprecedented performance.

Challenges: Particle agglomeration

FY2016 MILESTONES

1st Quarter of the project

Month /Year	Milestone or Go/No-Go Decision	Description	Status
March 2016	Milestone	Fabrication of exfoliated graphene nanoplatelets with tailored properties	COMPLETE
March 2016	Milestone	Demonstrate silica nanofibers with diameter smaller than 100nm according to SEM measurements	COMPLETE

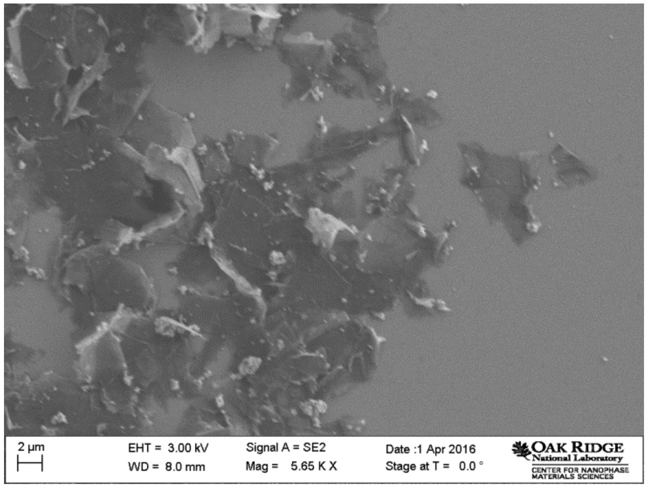
Assessment tools

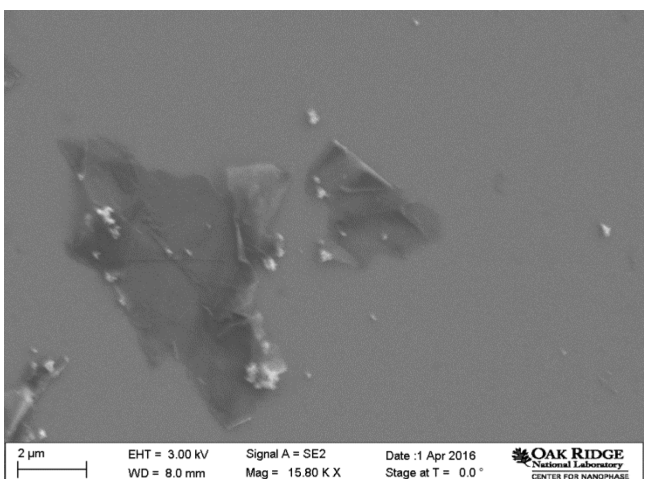
Scanning Electron Microscopy (SEM), Raman Spectroscopy

ACCOMPLISHMENT (1): Exfoliation of Graphene nanoplatelets

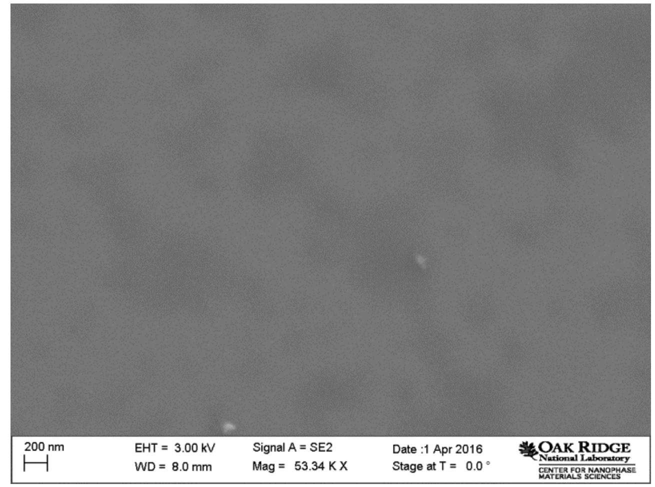
Exfoliation of graphene nanoplatelets in solution using high-shear mixing techniques and ultrasonic agitation

Graphene flake aggregates

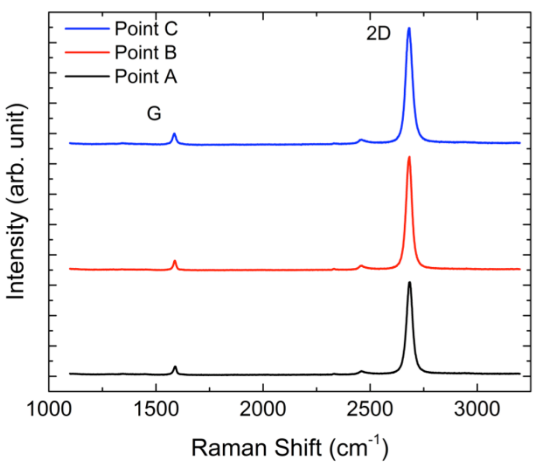




Exfoliated graphene



The number of monolayers is estimated using Raman spectroscopy



Graphene monolayer

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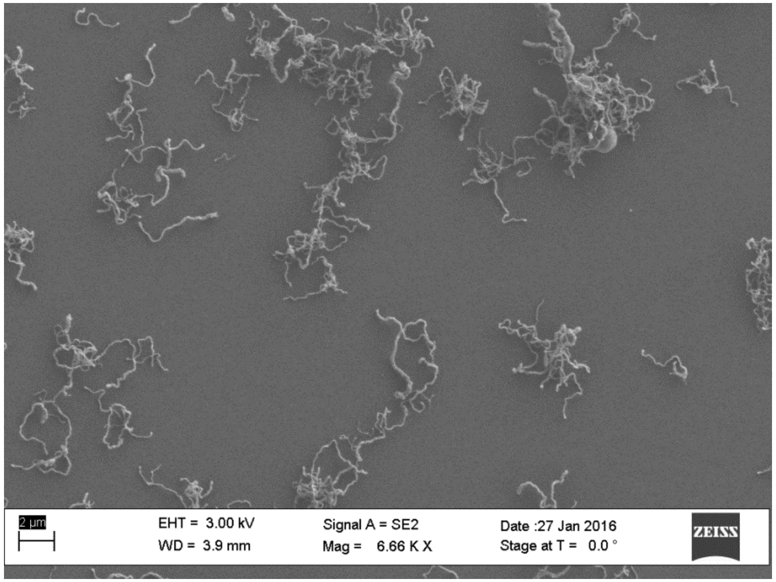
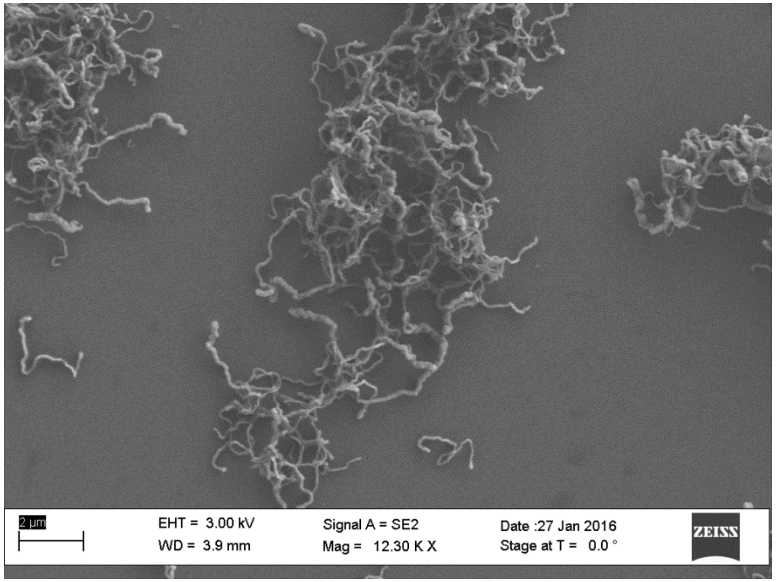
ACCOMPLISHMENT (2): Synthesize silica nanofibers with diameter smaller than 100nm

- **Silica nanofibers were synthesized in solution using polymer templates**
- **The diameter of the fibers is 85 - 110 nm**





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Ongoing work

2nd Quarter of the project

Month /Year	Milestone or Go/No-Go Decision	Description	Status
June 2016	Milestone	Functionalized graphene nanoplatelets readily available for dispersion in the elastomer matrix	
June 2016	Milestone	The silica nanofibers should demonstrate modulus values greater than 50 GPa	
June 2016	Milestone	Filler dispersion in the elastomer compound	

Assessment tools

X-ray photoelectron spectroscopy (XPS)

Thermogravimetric analysis (TGA)

Fourier transform infrared spectroscopy (FTIR)

Atomic-force microscopy (AFM)

Transmission electron microscopy (TEM)

SUMMARY:

- **Relevance**
  - To improve tire efficiency and meet DOE's fuel consumption reduction target of 4%, all while maintaining or improving wear characteristics of the tire.
- **Approach**
  - To replace existing fillers (such as carbon black and silica) with higher performance materials (viz., graphene and silica nanofibers).
- **Technical accomplishments and progress**
  - Synthesized silica nanofibers with diameter smaller than 100nm.
  - Fabrication of exfoliated graphene nanoplatelets with controlled number of layers.
- **Ongoing Work**
  - Functionalization of the filer particles.
  - Filler dispersion in the elastomer compound.

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