Boride-carbon hybrid technology to produce ultra-wear and corrosion resistant surfaces for applications in harsh conditions

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Michigan State University, Argonne National Laboratory & Fraunhofer USA Inc.

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Overview

Timeline

- Award in May 2018
- Projected end date November 2019
- One budget period

Budget Period I	
DOE Investment	$800,000
Cost Share	$200,000
Project Total	$1,000,000

Barriers

- Develop a **commercially feasible** treatment for making extremely durable low-friction wear and corrosion resistant surfaces.

Partners

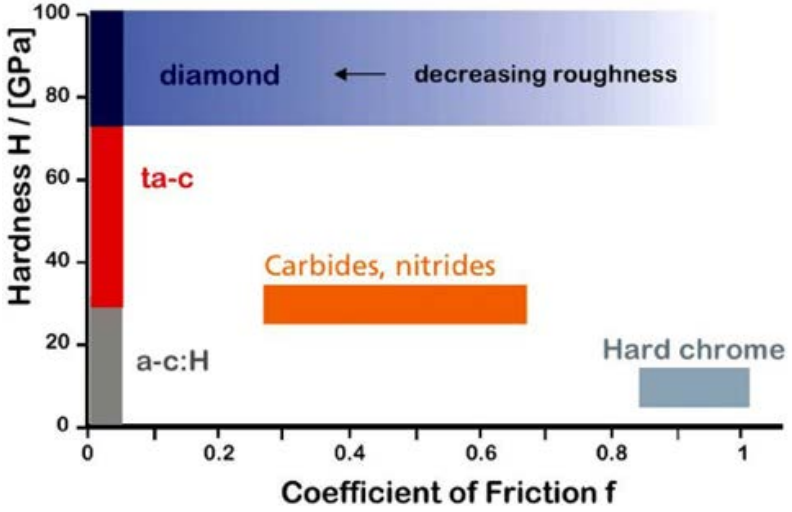
- Michigan State University (project management, coating technology)
- Argonne National Laboratory (boriding technology)
- Fraunhofer USA Inc. (coating technology)
- Industry partners (application specification and testing)

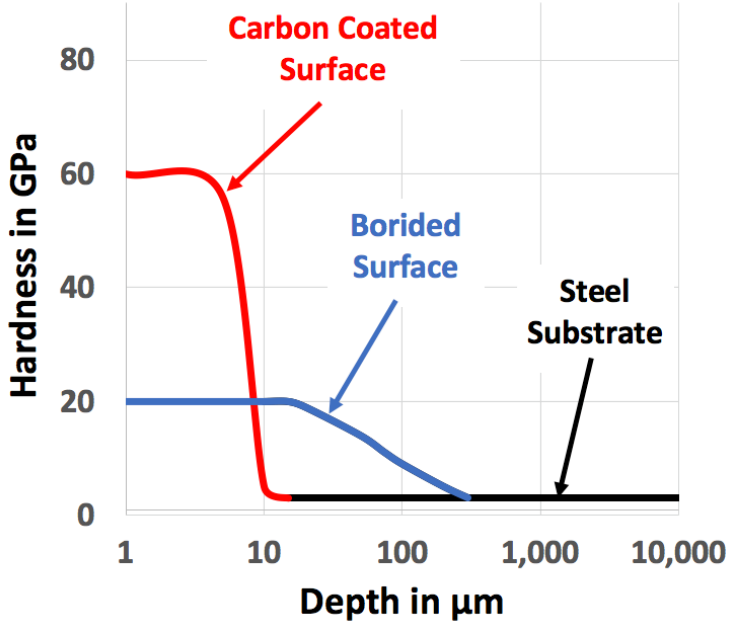
Objectives

- **Mechanical assemblies** (engines, transmissions, complex tools) experience ever **harsher operating conditions** (extreme contact loads, corrosive environments), while **durability** has to increase and **costs** have to decrease. Therefore this project aims:
  - To develop a hybrid process for creating **extremely durable low friction, wear and corrosion protective engineered surfaces** for tribological components in harsh conditions.
  - To **demonstrate the performance** of such surfaces on the laboratory scale.
  - To **demonstrate a commercialization path** via industry engagement and cost-benefit analysis to enable deployment across **transportation**, **renewable power** and **manufacturing** industries to reduce energy consumption and increase service life.

Technical Innovation – State-of-the-Art

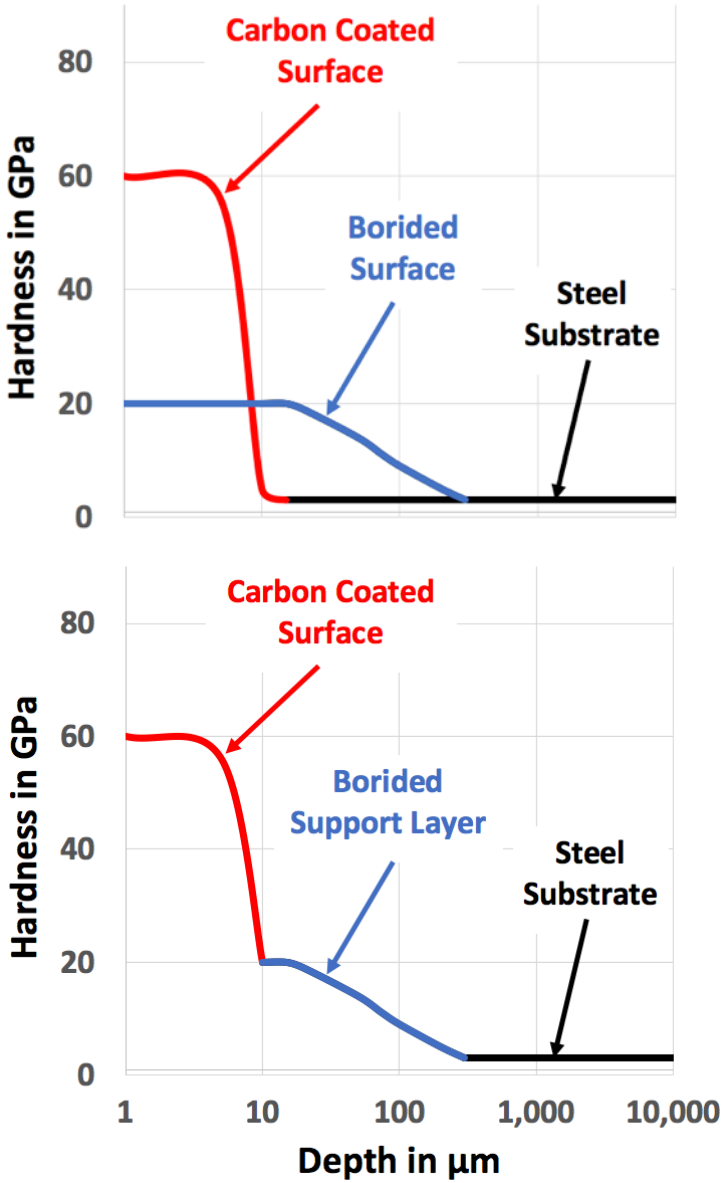
- Today's Surface Engineering:
  - Hard carbon coatings
  - Fast boriding
- Issues:
  - Insufficient mechanical **substrate support for** the hard **coating**
  - **Insufficient hardness** of borided layers for extreme applications
  - **Corrosive attack of substrate through pinholes in thin coating**





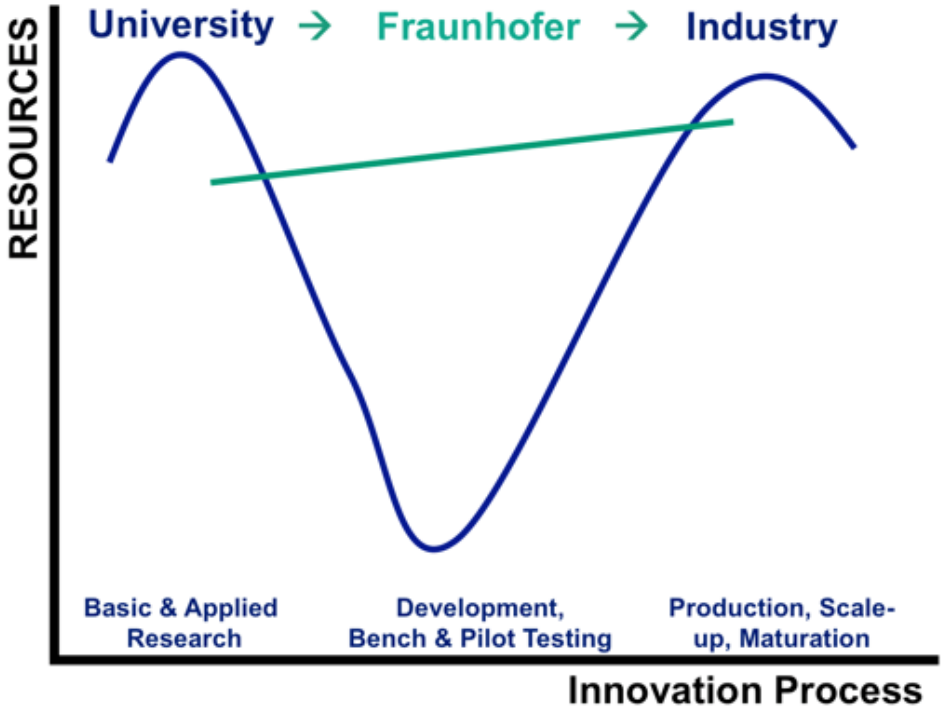
Technical Innovation – New Approach

- **Hybrid Treatment**: Fast Boriding + Hard Carbon Coatings
- Advantages:
  - Tailored **mechanical substrate** support for the hard coating by thicker boride support layer
  - **Corrosion protection** by thicker boride support layer
  - **Economical** due to ultra fast electrochemical boriding process



Technical Approach – Unique Attributes

- Unique collaboration to **bridge the innovation gap**:
  - University,
  - National Laboratory,
  - Fraunhofer,
  - Industry.
- **Risk reduction** through existing
  - Translational experience,
  - Equipment, infrastructure,
  - Precompetitive and cross-industrial approach.



MICHIGAN STATE UNIVERSITY

Argonne NATIONAL LABORATORY

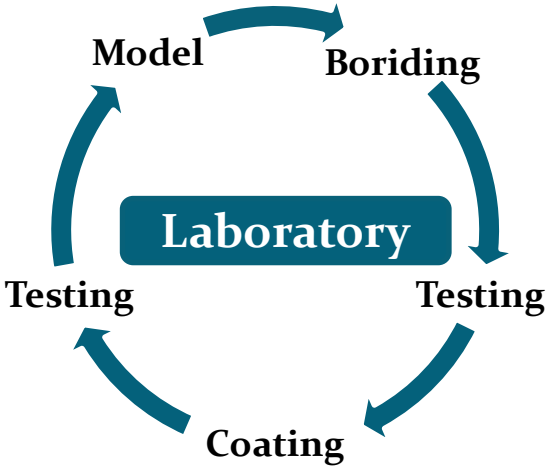
Fraunhofer

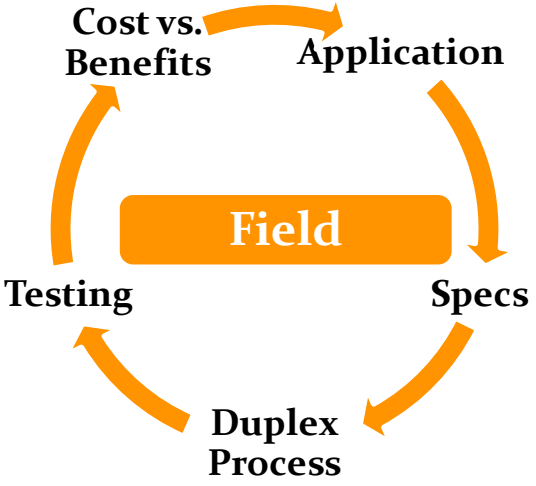
Cummins Fuel Systems

MERITOR

Technical Approach – Team Roles

Boriding	Argonne NATIONAL LABORATORY
Coating	MICHIGAN STATE UNIVERSITY; Fraunhofer USA
Lab Testing	Argonne NATIONAL LABORATORY; Fraunhofer USA
Appl. Specs	Cummins Fuel Systems; MERITOR
Duplex Process	Argonne NATIONAL LABORATORY; Fraunhofer USA
Field Testing	Cummins Fuel Systems; MERITOR





Results and Accomplishments

- As of June 2018: Project is in the process of being setup at Michigan State University, Argonne National Laboratory and Fraunhofer USA Inc.

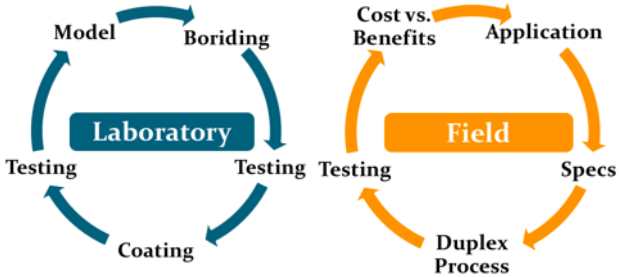
Target Performance of Duplex Treatment	
C-Coating adhesion on borided layer	HF1 according to VDI3198
Wear rate& friction coefficient	10^{-9} mm^3/Nm (ta-C vs. ta-C), μ = 0.1 (dry against steel)
Corrosion resistance	> 3 hours in 15% HCl
Fatigue strength (rolling/sliding)	+30%

Expected Benefits

- Costs of **friction** and **wear** in mechanical assemblies is **5%** of the **GNP** of most industrialized nations.
- Example – **Transportation** Industry
  - Combustion engines: **50% of the frictional losses** in **powertrain**. Worldwide this equals **100 billion liters** of fuel wasted combined with **emissions**.
  - USA: **28% of total energy** use goes to **transportation**
- What can the proposed technology do?
  - Reduce fuel consumption in highway trucks by at least 3% and extend engine life to > 1 million miles.
  - Example **Schneider National**: 10,000 trucks, 3 billion miles per year, 6 miles/gallon, 3% savings on fuel corresponds to more than 25% of their net income.

Transition

EERE Project → **Additional Application Development** → **Transfer & Implementation with Service Providers**



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Cummins Fuel Systems

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Who cares?

- Oil & gas,
- Mining,
- Rail vehicles,
- Heavy duty trucks,
- Cement and mineral processing,
- Hydro, wind and tidal energy,
- Automotive,
- …


Service provider facility

- **Component manufacturers** will work with **service providers** to treat parts adding value for the **end user**.
- If **benefits outweigh costs** for all, the technology will succeed as previous surface engineering technologies have demonstrated (e.g. coated cutting tools).

Questions?