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
• Project start date: 05/16/2018
• Project end date: 11/15/2019

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

AMO MYPP
• Materials for Harsh Service Conditions

<table>
<thead>
<tr>
<th>Budget</th>
<th>DOE Share</th>
<th>Cost Share</th>
<th>Total</th>
<th>Cost Share %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Budget</td>
<td>$550,000</td>
<td>$200,000</td>
<td>$750,000</td>
<td>26.7%</td>
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<tr>
<td>Costs as of 3/31/19</td>
<td>$219,444</td>
<td>$154,977</td>
<td>$374,420</td>
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</tbody>
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Partners
• Michigan State University (project management, coating technology)
• Argonne National Laboratory (boriding technology)
• Fraunhofer USA Inc. (coating technology)
• Industry partners (application specification and testing)

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Project 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.

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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

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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

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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.

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Technical Approach – Team Roles

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Results and Accomplishments

Milestones
• Diamond and ta-C coatings with good adhesion on borided parts made from industry relevant steels

Accomplishments
• Duplex layers have better wear and corrosion resistance than single layers
• In contact with end-users

Future Work
• Fatigue Performance
• End-user specifications
• Cost-benefit model

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Transition

EERE Project  Additional Application Development  Transfer & Implementation with Service Providers

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

- 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).

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