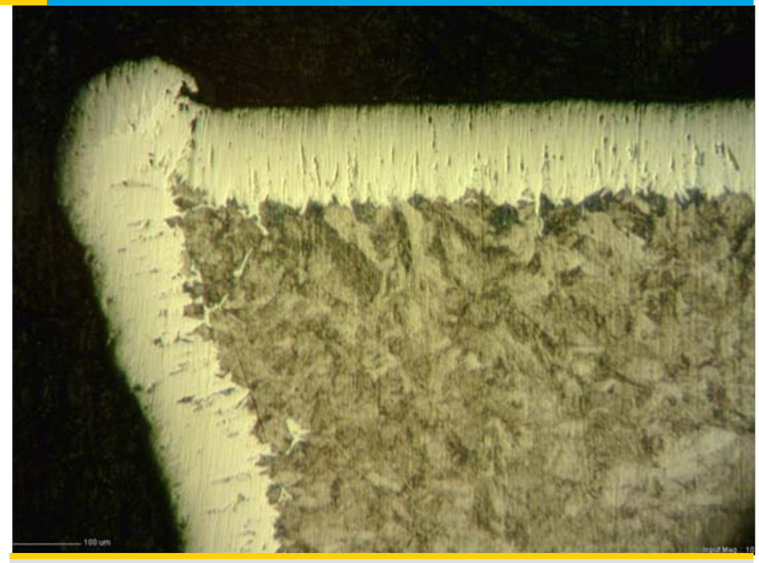
Ultrafast Boriding in High-Temperature Materials Processing Industries

Improved Energy Efficiency and Reduced Emissions in High-Temperature Materials Processing



Cross-sectional image of an ultrafast borided steel part.

Image courtesy of Argonne National Laboratory.

Introduction

U.S. manufacturing firms use a variety of heat treatments (such as nitriding, carburizing, carbonitriding, boriding, etc.) and coating technologies (such as physical and chemical vapor deposition, laser-glazing/-cladding, ion-beam deposition, etc.) to improve the performance and durability of machine tools and other mechanical components. However, these traditional technologies can be very time-consuming, expensive, energy-intensive, and environmentally sensitive. To improve the competitiveness of companies involved in heat and/or surface treatment practices, there is an imminent need to develop more cost effective, energy-efficient, and more green materials processing technologies.

Researchers will develop, optimize, scale-up, and transfer for commercial use an ultrafast boriding (or boronizing) process that can provide much higher energy efficiency, productivity, and near-zero emissions in high-temperature materials processing.

Ultrafast boriding could be a transformational and enabling technology with a high potential to displace, and/or complement, many of the very energy-intensive surface treatment processes in use today. When fully developed and implemented, the technology can provide an alternative for high-temperature surface enhancement techniques; improve energy efficiency; help near-net shape manufacturing; and provide a new means for the processing of conventional materials and components. Since the boriding process operates at about 200°C cooler, it saves energy and extends the useful life of components.

Benefits for Our Industry and Our Nation

This boriding method is very fast, clean, efficient, and has lower cost than more energy-intensive heat treatment and coating methods. Ultrafast boriding could consume only 15% of the energy used in conventional pack boriding.[1]

From an environmental standpoint, ultrafast boriding does not produce any type of gaseous emissions, nor does it create solid and/or liquid wastes to cause concern.

There are several economic benefits of Ultrafast boriding. It can increase productivity and product quality by shortening treatment time and by enabling much deeper and harder surface layers on borided parts (which can prolong life in actual applications). It can also markedly reduce cost due to initial capital investments as well as in-plant operations and maintenance.

Applications in Our Nation's Industry

Ultrafast boriding is ideal for the treatment of iron and steel-based materials but it can also be used for the treatment of certain nonferrous metals and their alloys (e.g., titanium, tantalum, zirconium, tungsten, niobium, molybdenum, magnesium, most nickel-based and cobalt-based superalloys, and cobolt-chrome alloys) and cermets. Pre-carburized, nitrided, and carbonitrided steels and non-ferrous alloys can also be treated by the new boriding technique.

Project Description

The main objective of this project is to further develop, optimize, scale-up, and transfer for commercial use an ultrafast boriding (or boronizing) process that can provide much higher energy efficiency, productivity, and near-zero emissions in many of the high-temperature materials processing industries.

Other goals of this project are to demonstrate scalability, cost-competitiveness, superior property, performance, and durability characteristics of the ultrafast borided surfaces as well as transferring the optimized technology to an industry partner.

Barriers

- Start-up cost related to capital equipment and/or construction of a large process cell.
- The ability to uniformly boride intricate or odd-shaped samples or components uniformly in large batches.
- The ability for the process to demonstrate dimensional predictability and minimize distortion from high-temperature processing.
- Demonstrating system controls and operating practice that result in process predictability and reliability
- Demonstrating reliability of boriding equipment heating system and furnace design

Pathways

Researchers will mainly focus on the scalability and viability of the new process for a broad spectrum of industrial applications and materials. The team will also perform extensive structural, chemical, mechanical, and tribological characterizations of the borided surfaces using a large variety of microscopic, tribological, and surface analytical tools. Effects of contact pressure, temperature and other test parameters will be studied in detail and appropriate friction and wear maps will be generated. These bench tests will be followed by extensive performance and durability tests in actual or intended applications. Industrial and economic impacts of this new technology will also be assessed.

Milestones

This project started in September 2008.

- Process development and optimization: design and develop a medium-size ultrafast boriding unit and demonstrate the feasibility of larger-scale processing using test samples and industrial parts. (Completed)
- Technology development and field verification: study technology maturation, process validation, and field performance testing of a large number of industrial parts and components. (Completed)
- Scale-up, validation, and technology transfer: build, install, and start-up an industrial-scale boriding system; prove the production of borided parts and components with an industrial partner, resulting in licensing of the technology for commercialization

Commercialization

After proven successful, the technology will be transferred to Bodycote for full-scale commercialization. Bodycote will obtain a license from Argonne and will build several production units. Bodycote will then start the production of borided parts for commercial sale. Once the technology is fully operational, sales will be expanded to other geographical areas.

Project Partners

Argonne National Laboratory
Argonne, IL
Principal Investigator: Ali Erdemir
E-mail: erdemir@anl.gov
Technology Transfer Manager: William D. Ingle
E-mail: wingle@anl.gov

Bodycote Thermal Processing – Americas
Melrose Park, IL
Principal Investigator: Mario Ciampini
E-mail: mario.ciampini@bodycote.com

For additional information, please contact

Stephen Sikirica
Technology Manager
U.S. Department of Energy
Industrial Technologies Program
Phone: (202) 586-5041
E-mail: stephen.sikirica@ee.doe.gov

(end note)

[1] Based on data provided by Bodycote Thermal Processing

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