Environmental Review Form for Argonne National Laboratory

Click on the blue question marks (?) for instructions, contacts, and additional information on specific line items.

(?)Project/Activity Title: Ultra Fast Boriding for Improved Efficiency

(?)ASO NEPA Tracking No.		<u>(?)Type of Funding</u> : <u>DOE-EERE-ITP</u> B&R Code		
(?)Identifying number: Work Project # Other (explain)	WFO proposal # ANL accounting # (iten	CRADA p 1 3a in Field Work Pr	oroposal # oposal)	
(?)Project Manager: Ali Erdemir	Signature:	1 toling	Date: 10/25/10	
(?)NEPA Owner: Roberta Riel	Signature: Role	wha ful	Date: 10/22/10	
ANL NEPA Reviewer: <u>M. A. Kam</u>	iya Signature: <u>C</u>	. Almarga	$Date: \frac{10 \left 25 \right 2010}{2010}$	

I. (?)Description of Proposed Action:

The main objectives of work are to further optimize, demonstrate the ultra-fast boriding process in manufacturing scale as an alternative new technology in the field of high-temperature materials processing and in order to achieve higher energy efficiency and productivity, lower cost, and near-zero emissions in heat treating industries. Other important goals are to demonstrate the superior performance and durability of borided parts in industrial applications, and to transfer optimized technology to our industrial partner.

Like nitriding and carburizing, boriding is an important surface treatment process in which boron atoms diffuse into the near surface region of a work piece and react with the metallic constituents to form a layer of hard boride phases. In the case of ferrous alloys, boride layer consists primarily of Fe2B and FeB phases. A very thick boron diffusion zone also exists beneath the boride layers and provides good mechanical support for the top layer. Iron borides are chemically very stable and mechanically rather hard. Therefore, when present as dense layers on a surface, they can substantially increase the resistant of these surfaces to corrosion, adhesive, abrasive and erosive wear.

Among all boriding techniques, pack-boriding is the most widely used one. The pack usually contains large amounts (about 90%) of carrier powder material (like SiC), a source of boron (like boron carbide or amorphous boron), and an activator (like KBF₄) to enhance diffusion of atomic boron into the work piece. Pack boriding involves placing the work pieces into the powder mix and sealing it in a container. The container is then heated up to around 950°C and held there for 4 to 8 hours and finally cooled down in air. The thickness of the boride layers is determined by the process temperature and duration but typically is in the range of 20 to 50 μ m. Powders used in the pack pose difficult waste management and disposal problems and are not easy to recycle or reuse. However, as the name implies, the ultra-fast boriding process of this project is extremely-robust and hence has the potential to replace most of the energy intensive traditional boriding, carburizing, and nitriding processes that are in use today. In a low carbon steel (AISI 1018) sample, the new boriding process can produce 90 to100 micrometer-thick boride layers within 30-40 minutes. It would have taken more than 20 hours to achieve similar case depths by the fastest boriding method (which is pack-boriding) in use today.

This project involves the use of a manufacturing scale Ultra-Fast Boriding furnace for boronizing. The furnace has a pot (made out of silicon carbide (SiC) bricks) that holds approximately $6,000 (\pm 10\%)$ lbs. of electrolyte (melt) at a temperature range of 750-1000 °C. The electrolyte composition will be initially 100

% Borax (Na₂B₄O₇). We may withdraw 10% (wt.) of the borax and replace it with 10% (wt.) sodium carbonate (Na₂CO₃), depending on the initial experimental results. The industrial parts will be placed in SiC pot in the furnace by using stainless steel fixtures. Once the temperature reaches the target (700 -1000 °C, experiment dependent) and is stabilized, the leads from the DC power supply will be connected to the electrode and steel specimen. A current to maintain current density up to 0.5 A/cm2 will be applied. The electrolysis will be done for up to 2 hours, and then the parts will be withdrawn from the melt.

Anode material is graphite (Shape is $40^{\circ}x30^{\circ}x1^{\circ}$ thick plate -) and it will be immersed into the melt and some of the graphite anode will stay above the melt. There will be 316 stainless steel (SS) connections in that top zone. There will be 4 anodes in the system.

Cathode is the part that will be borided. The parts are made out of carburized low carbon steel and the fixtures that hold those parts will be made out of 316 stainless steel. The dimensions will be similar to anode dimensions (1"x40"x30"). There will be 3 cathodes in the system.

Anodes will stay in the melt for 6 months (only if necessary will the anodes be changed with the new ones). The cathodes will remain in the melt during the boriding process (typically 1-2 hours). In each boriding process, the same 316 SS fixtures will be used but new parts will be placed into those fixtures. There will be a top cover on the pot and the inside of the pot will be purged with Nitrogen gas to create inert environment. The purpose of nitrogen purging is to increase the life of the SiC bricks, anode and cathode fixtures in the splash zone, by minimizing the oxidation.

II. (?)Description of Affected Environment:

The Ultra-Fast Boriding Project will be conducted indoors within the building 370 Hi-Bay, which has been previously disturbed. The proposed addition of the Ultra-Fast Boriding Project within building 370 would have no significant environmental impact.

Existing utilities are planned to be used; however, electrical components will be installed and connected to existing transformers and motor control centers. Approximately 1800 Sq Ft of space is allocated for this furnace and other experimental components. Experimental components are the large boriding furnace, 20V 8000A DC boriding power supply, step-down transformer (480 volt primary & 240 volt secondary) for furnace heaters, pre-heating furnace (goes up to 750 F), fixtures and fixture racks, walking platform, and a computer rack. There is no construction work required for this project since the on-site electrical contractor will be used along with shops/crafts for the duct/piping work.

The project is using large quantities (~6,000 lbs.) of Borax (Na₂B₄O₇) and Sodium carbonate (Na₂CO₃). A manufacturing scale furnace (heated by SiC electric heaters) has been purchased for this project. There is a ceramic pot in this furnace that will hold the melt. In addition, there is a 0.5" fully welded thick metal liner outside of the brick pot which will act as a secondary container if the brick pot fails to hold the liquid melt.

III. <u>(?)Potential Environmental Effects:</u> (Attach explanation for each "yes" response. See Instructions for Completing Environmental Review Form)

A. Complete Section A for all projects.

1. (?)Project evaluated for Pollution Prevention and Waste Minimization opportunities and details provided under items 2, 4, 6, 7, 8, 16, and 20 below, as applicable

The system uses the same borax $(Na_2B_4O_7)$ and borax/sodium carbonate mixture melt for the entire boriding operations. Approximately, twelve 55 gallon drums will be filled with this melt at the end of the project. If the borax/sodium carbonate mixture is identified as

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Yes <u>X</u> No _____

hazardous waste, it will be disposed properly through Argonne Waste Management operations. If it is identified non-hazardous (Please keep in mind that the borax/sodium carbonate mixture will be usable in the boriding process) we may give this mixture to our industrial partner to enable them to use it in their boriding system or dispose it through Argonne Waste Management Operations.

2. (?)Air Pollutant Emissions

Yes X No

Yes _____ No ___X

Yes X No

There is no ventilation stack or hood on the furnace. We initially plan to use 100 % borax to form the melt and there will be no emissions with this stage. If our experimental work requires the use of Sodium Carbonate (Na₂CO₃), we will be using a maximum 600 lbs of this chemical, then CO₂ emissions may occur due to decomposition of Na₂CO₃ to Na₂O+CO₂ over time. These extremely low amounts of CO₂ emissions would go directly into the Bldg. 370 HiBay.

Our calculations show that the amount of CO_2 emissions would be a maximum of 249 lbs (113 kg) over the life of the project. Considering the estimated duration of the furnace usage (minimum 6 months), this reflects as 1.38 lbs (0.62 kg) CO₂ emission per day which is extremely low. As a reference, human breathing produces approximately 2.3 pounds (1 kg) of carbon dioxide per day per person.

- 3. <u>(?)</u>Noise
- 4. (?)Chemical Storage/Use

6,000 lbs. of borax (Na₂B₄O₇) and 600 lbs. of sodium carbonate (Na₂CO₃) will be used. The initially prepared melt, will be re-used during entire boriding operation for approximately six months. Borax and sodium carbonate materials (before and after usage) will be stored in allocated space in building 370. The chemical will be in the form of 1000 or 2000 lbs super sacks before experimental work and will be in solid form in 55 gallon drums after the experimental work is completed.

Loading of chemical into the pot will be handled by using a screw conveyor and a type of funnel, while the top cover of the pot is in place. This will prevent any dust in work area or spillage. The overhead crane will be used during emptying the pot at the end of experiments and liquid melt will be placed into unpainted drums with a bail-out bucket connected to the overhead crane. A fully welded secondary metal container inside of the furnace will prevent any liquid melt leakage from the pot. In addition, there will be several thermocouples connected to the metal liner, temperature increase will be an indicator of leakage from the bricks and the liquid melt reaching the secondary containment. If this happens the furnace will automatically shut down.

5.	(?)Pesticide Use	Yes	No	X
6.	(?) Polychlorinated Biphenyls (PCBs)	Yes	No	X
7.	(?) Biohazards	Yes	No	<u>X</u>
8.	(?)Liquid Effluent (wastewater)	Yes	No	X
9.	(?)Waste Management			
	a) Construction or Demolition Waste	Yes	No	х

Hazardous Waste b)

Yes X No The inventory of chemicals would not be excessive relative to the amount required to conduct the research, thus minimizing disposal of unneeded materials. Incompatible chemicals would be segregated. All storage of chemicals would conform to the requirements in Argonne's Environment, Safety and Health Manual or LMS Procedures. The inventory of chemicals would be entered into Argonne's centralized electronic inventory system.

Our small scale experimental work showed that the mixture of borax (Na₂B₄O₇) and sodium carbonate (Na₂CO₃) may attack and dissolve chromium (Cr) in the stainless steel fixtures and possibly make the melt (above 5 ppm level of Cr) a Hazardous waste. We did not see an evidence of Cr dissolution, when pure borax $(Na_2B_4O_7)$ was used. In the manufacturing scale system, pure borax $(Na_2B_4O_7)$ and sodium carbonate (Na₂CO₃), will be used. We will avoid or minimize use of stainless steel fixtures. However, there is still a possibility to generate hazardous waste due to Cr dissolution. At the end of the work, if the melt is identified as hazardous waste after conducting TCLP analysis, it will be disposed of properly through Argonne Waste Management Operations. If it is identified non-hazardous (Please keep in mind that the borax/sodium carbonate mixture will be usable in the boriding process) we may give this mixture to our industrial partner to enable them to use it in their boriding system or dispose it through Argonne Waste Management Operations.

	c)	Radioactive Mixed Waste	Yes	No	X
	d)	Radioactive Waste	Yes	No	X
	e)	PCB or Asbestos Waste	Yes	No	Χ
	f)	Biological Waste	Yes	No	X
	g)	No Path to Disposal Waste	Yes	No	<u>X</u>
	h)	Nano-material Waste	Yes	No	X
10	<u>(?)</u> R	adiation	Yes	No	X
11	<u>(?)</u> T	hreatened Violation of ES&H Regulations or Permit Requirements	Yes	No	<u>X</u>
12	<u>(?)</u> N	lew or Modified Federal or State Permits	Yes	No	X
13.	(?)S Tre	iting, Construction, or Major Modification of Facility to Recover, eat, Store, or Dispose of Waste	Yes	No	X
14	<u>(?)</u> P	ublic Controversy	Yes	No	<u>X</u>
15.	. <u>(?)</u> H	listoric Structures and Objects	Yes	No	<u>X</u>
16	. <u>(?)</u> D	Pisturbance of Pre-existing Contamination	Yes	No	X
17.	(?)E and	nergy Efficiency, Resource Conserving, I Sustainable Design Features	Yes <u>X</u>	No	

The main objective of this project is to minimize energy consumption and GHG emissions in the boriding industry. With this new process, overall energy savings are estimated to be up to 80% compared to traditional boriding.

	В.	For projects that will occur outdoors, complete Section B as well	as Section A.	NA
· ·	18.	(?)Threatened or Endangered Species, Critical Habitats, and/or other Protected Species	Yes	No
	19.	(?)Wetlands	Yes	No
	20.	(?)Floodplain	Yes	No
	21.	(?)Landscaping	Yes	No
	22.	(?)Navigable Air Space	Yes	No
	23.	(?)Clearing or Excavation	Yes	No
	24.	(?)Archaeological Resources	Yes	No
	25.	(?)Underground Injection	Yes	No
	26.	(?)Underground Storage Tanks	Yes	No
	27.	(?)Public Utilities or Services	Yes	No
	28.	(?)Depletion of a Non-Renewable Resource	Yes	No
	C.	For projects occurring outside of ANL complete Section C as we	ll as Sections A	and B.
	29.	(?)Prime, Unique, or Locally Important Farmland	Yes	No
	30.	(?)Special Sources of Groundwater (such as sole source aquifer)	Yes	No
	31.	(?)Coastal Zones	Yes	No
	32.	(?)Areas with Special National Designations (such as National Forests, Parks, or Trails)	Yes	No
	33.	(?)Action of a State Agency in a State with NEPA-type Law	Yes	No
	34.	(?)Class I Air Quality Control Region	Yes	No
IV.	<u>Sub</u>	part D Determination: (to be completed by DOE/ASO)		
	Are may	there any extraordinary circumstances related to the proposal that affect the significance of the environmental effects of the proposal?	Yes	No X
	Is the or re	e project connected to other actions with potentially significant impact lated to other proposed action with cumulatively significant impacts?	ïS Yes	No X
	If ye or 10	s, is a categorical exclusion determination precluded by 40 CFR 1506. O CFR 1021.211?	.1 Yes	No
	Can of ar unde	the project or activity be categorically excluded from preparation a Environment Assessment or Environmental Impact Statement or Subpart D of the DOE NEPA Regulations?	Yes X _	No

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Appendix B

If yes, indicate the class or classes of action from Appendix A or B of Subpart D under which the project may be excluded. <u>B 3.6 Siting /Construction/Operation/</u> Decommissioning of facilities for bench-scale research, conventional laboratory operations, small-scale research and development and Pilot projects.

If no, indicate the NEPA recommendation and class(es) of action from Appendix C or D to Subpart D to Part 1021 of 10 CFR.

ASO NEPA Coordinator Review:	
Signature:Kaushik N. Joshi	Date: 11-1-2010
ASO NCO Approval of CX Determination: The preceding pages are a record of documentation that a further NEPA review under DOE NEPA Regulation 10 C proposed action meets the requirements for the Categorical Signature: Peter R. Siebach Acting Argonne Site Office NCO	In action may be categorically excluded from FR Part 1021.400. I have determined that the Exclusion identified above. Date: $11/3/20/0$
ASO NCO EA or EIS Recommendation:	
Class of Action:	_
Signature: Peter R. Siebach Acting Argonne Site Office NCO	Date:
Concurrence with EA or EIS Recommendation:	
CH GLD:	
Signature:	Date:
ASO Manager Approval of EA or EIS Recommendation	• NA
AnEAEIS shall be prepared for the proposed	dand
shall serve as the document manage	èr.
Signature: Dr. Joanna M .Livengood Manager	Date:
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