OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

NFE-11-03444

Materials Science & Technology Division

CRADA Final Report
For
CRADA Number NFE-11-03444

NanoComposite Stainless Steel Powder Technologies

Ryan Dehoff, PhD.
Oak Ridge National Laboratory

Curt Glasgow
MesoCoat, Inc.

Prepared by
Oak Ridge National Laboratory
Oak Ridge, TN 37831
managed by
UT-BATTELLE, LLC
for the
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1 Project Objective

The objective of this Cooperative Research and Development Agreement (CRADA) between UT-Battelle (hereinafter the "Contractor") and MesoCoat Inc., (hereinafter the "Participant") is to utilize and evaluate NanoComposite Stainless Steel Powder as a coating technology for increased wear and corrosion resistance of component material.

2 Background

Oak Ridge National Laboratory has been investigating a new class of Fe-based amorphous material stemming from a DARPA, Defense Advanced Research Projects Agency initiative in structural amorphous metals. Further engineering of the original SAM materials such as chemistry modifications and manufacturing processes, has led to the development of a class of Fe based amorphous materials that upon processing, devitrify into a nearly homogeneous distribution of nano sized complex metal carbides and borides. The powder material is produced through the gas atomization process and subsequently utilized by several methods; laser fusing as a coating to existing components or bulk consolidated into new components through various powder metallurgy techniques (vacuum hot pressing, Dynaforge, and hot isostatic pressing). The unique fine scale distribution of microstructural features yields a material with high hardness and wear resistance compared to material produced through conventional processing techniques such as casting while maintaining adequate fracture toughness. Several compositions have been examined including those specifically designed for high hardness and wear resistance and a composition specifically tailored to devitrify into an austenitic matrix (similar to a stainless steel) which poses improved corrosion behavior.

3 Technical Status

ORNL supplied the participant with two different chemistries of material designated NC-8 and SSAM (designated as such for intellectual property purposes) in two different powder size distributions, -325 mesh and +325 – 100 mesh. MesoCoat deposited the powders utilizing thermal spray technology, high velocity oxy-fuel process (HVOF), onto 1008 steel material. A parametric study was performed on parameter optimization of temperature, traverse speed, carrier gas, fuel ratio, etc. ORNL characterized the microstructural of the samples. The microstructure appeared homogeneous although EDS analysis indicated particular elements had a tendency to segregate during processing, an example being tungsten rich precipitates. Although the coating adhered to the substrate, evaluation using scanning electron microscopy showed porosity at the interface between the coating and the substrate. Porosity was also evident, although minimal, throughout the thickness of the coating itself. Optimization of process parameters maximized bonding to the substrate and minimized porosity.

HVOF samples were compared to laser fused samples of stainless SAM and NC-8 deposited on similar substrate materials (4340 and H13 steel). Although the HVOF samples were not fully dense, they appeared to have consistently even coverage over the surface in contrast to laser deposited materials that show evidence of thermal cracking during the fusing process. The thermal cracking evident on laser fused materials penetrate into the substrate material which may not fully protect the substrate material in corrosive environments. The microstructure of the HVOF materials may provide better corrosion resistance than laser fused materials depending on the environment.

In addition to the thermal spray process, MesoCoat also utilized the CermaClad™ process to apply the materials as a cladding to steel substrate material. This is a high energy density fusion cladding process for large area applications where corrosion and/or wear limit the life of metal structures. Although there is a small heat affected zone, the process fully melts and solidifies the powder material. Evidence of the melting process is observed in the microstructure of the coating materials after processing. The resulting microstructure is dendritic in nature, typical of a solidification microstructure. Examination revealed partial melting of the substrate material as well that resulted in a metallurgical bond between the substrate and coating material although small amounts of residual porosity remained in the coating. Hardness values were measured for both coatings, NC-8 and SSAM, deposited using the CermaClad™ process and ranged from 900-1000hV and 400-600hV respectively. The hardness values are lower (~200-300hV) than deposition of the coating via laser processing, however the CermaClad™ processed coating did not contain any evidence of cracking as can be found with laser deposited material, indicating the CermaClad™ process may be the ideal deposition technology for these materials.

4 Technical Plans for Next Quarter

The project is considered complete. ORNL is awaiting the results of abrasive tests being performed on the components. No additional costs are expected for ORNL. These writings shall be considered the final report.

5 Commercialization Status

None

6 Commercialization Plans for Next Quarter

None planned

7 Invention Disclosures

None planned

8 Publications/Presentations

None planned

9 Schedules and Budget Tables

Task Schedule

Task Number	Task Description	Task Completion Date				Progress Notes
		Original Planned	Revised Planned	Actual	Percent Complete	
1	Determination of Component	4/1/2011	6/15/2011	7/15/2011	100%	
2	Coating of Component	7/15/2011		3/1/2012	100%	
3	Evaluation of Coated Material	9/15/2011		3/1/2012	100%	
4	In-Field testing of Coated Component	3/1/2012			0%	Additional Laboratory testing is required prior to in-field testing
5	Completion of final CRADA report	3/01/12	7/1/12	7/1/12	100%	
1	Determination of Component	4/1/2011	6/15/2011	7/15/2011	100%	

Spending Schedule

Task	Approved Budget	Project Expenditures	
		This Quarter	Cumulative to Date
Task 1 Determination of Component	$3,000	$0	$3,000
Task 2 Coating of Component	$15,000	$0	$0,000
Task 3 Evaluation of Coated Material	$20,000	0	$43,000
Task 4 In-Field testing of coated component	$10,000	0	0
Task 5 Final CRADA report	$2,000	0	$2,000
Total	$50,000	0	$48,000
DOE Share	$50,000	0	$48,000

Cost Share Contributions

Funding Source	Approved Cost Share		This Quarter		Cumulative to Date	
	Cash	In-Kind	Cash	In-Kind	Cash	In-Kind
MesoCoat Inc.		$38,000				$38,000
Total		$38,000		0		$38,000
Cumulative Cost Share Contributions					$38,000	

Project Spending and Estimate of Future Spending							
Calendar Year Quarter	**From**	**To**	**Estimated Federal Share of Outlays***	**Actual Federal Share of Outlays**	**Estimated Recipient Share of Outlays***	**Actual Recipient Share of Outlays**	**Cumulative Actual Outlays (Federal + Recipient)**
3Q11	6/10/11	6/30/11	$3,000	$0		0	
4Q11	7/31/11	9/30/11	$10,000	$48,000			$48,000
1Q12	10/1/11	12/31/11	$20,000	$0			
2Q12	1/1/12	3/31/12	$15,000	$0		0	
3Q12	4/1/12	6/10/11	$2,000	$0			
Totals			**$50,000**	**$48,000**	**$50,000**	**$38,000**	**$96,000**

* CRADA took 9 months to complete; start date was June 10, 2010.

General Note: The information in this table should be consistent with the information provided in section 10 of the quarterly financial status reports (SF269 or SF269A).

Estimates should be provided for the entire project, and actuals should be provided for each quarter as it is completed. Estimates should be updated each quarter.

10 Acknowledgements

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