



AFRL-AFOSR-VA-TR-2022-0432

Fundamental Mechanistic Investigations of Additively Manufactured Multi-Phase Hybrid Materials

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07/27/2022
Final Technical Report

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REPORT DOCUMENTATION PAGE

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1. REPORT DATE 20220727	2. REPORT TYPE Final	3. DATES COVERED <table style="width: 100%;"> <tr> <td style="width: 50%;">START DATE 20170915</td> <td style="width: 50%;">END DATE 20200914</td> </tr> </table>		START DATE 20170915	END DATE 20200914	
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4. TITLE AND SUBTITLE Fundamental Mechanistic Investigations of Additively Manufactured Multi-Phase Hybrid Materials						
5a. CONTRACT NUMBER	5b. GRANT NUMBER FA9550-17-1-0345	5c. PROGRAM ELEMENT NUMBER 61102F				
5d. PROJECT NUMBER	5e. TASK NUMBER	5f. WORK UNIT NUMBER				
6. AUTHOR(S) Thomas Scharf						
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) UNIVERSITY OF NORTH TEXAS 1155 UNION CIR #305250 DENTON, TX 76203 USA			8. PERFORMING ORGANIZATION REPORT NUMBER			
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Office of Scientific Research 875 N. Randolph St. Room 3112 Arlington, VA 22203		10. SPONSOR/MONITOR'S ACRONYM(S) AFRL/AFOSR RTA1	11. SPONSOR/MONITOR'S REPORT NUMBER(S) AFRL-AFOSR-VA-TR-2022-0432			
12. DISTRIBUTION/AVAILABILITY STATEMENT A Distribution Unlimited: PB Public Release						
13. SUPPLEMENTARY NOTES						
14. ABSTRACT In recent years, additive manufacturing has gained increasing interest to produce novel near-net shape components. In contrast to conventional manufacturing techniques, like casting, we have determined that tailoring of microstructures along the build direction can achieve desired room and elevated temperature mechanical and wear properties for different alloys in the Ni-Al-Cr-C system. Specifically, we have explored laser additive manufacturing of novel hybrid materials with microstructures composed of solid solution strengthening and precipitation strengthening of a γ/γ' dendritic matrices, along with a distribution of reinforcing in situ formed hard ceramic (chromium carbides) and solid lubricant (graphite) phases. Such compositional modification of chromium and carbon were determined to drastically affect the corresponding phase morphology and properties, as determined by experimental and solution thermodynamic simulations. In addition, these laser deposited Ni-Al-Cr-C alloys could potentially be used for high temperature bearing houses that still require the need for high temperature solid lubrication at temperatures $>400^{\circ}\text{C}$, where current M50 steels exhibit oxidation issues leading to loss in rolling contact fatigue resistance. Mechanistic studies using surface and subsurface scanning and transmission electron microscopies in the wear surfaces revealed a combination of increased hardness/load-bearing and formation of tribochemical protective oxide glaze layers that were responsible for mitigating room and elevated temperature wear.						
15. SUBJECT TERMS						
16. SECURITY CLASSIFICATION OF: <table style="width: 100%;"> <tr> <td style="width: 33%;">a. REPORT U</td> <td style="width: 33%;">b. ABSTRACT U</td> <td style="width: 33%;">c. THIS PAGE U</td> </tr> </table>		a. REPORT U	b. ABSTRACT U	c. THIS PAGE U	17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 3
a. REPORT U	b. ABSTRACT U	c. THIS PAGE U				
19a. NAME OF RESPONSIBLE PERSON MATTHEW KRISAK			19b. PHONE NUMBER (Include area code)			

REPORT DOCUMENTATION PAGE					<i>Form Approved</i> OMB No. 0704-0188	
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1. REPORT DATE (DD-MM-YYYY) 12/08/2020		2. REPORT TYPE Final			3. DATES COVERED (From - To) 9-15-2017-9-14-2020	
4. TITLE AND SUBTITLE Fundamental Mechanistic Investigations of Additively Manufactured Multi-Phase Hybrid Materials				5a. CONTRACT NUMBER FA9550-17-1-0345		
				5b. GRANT NUMBER		
				5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S) Thomas W. Scharf (PI) Rajarshi Banerjee (co-PI)				5d. PROJECT NUMBER		
				5e. TASK NUMBER		
				5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) UNIVERSITY OF NORTH TEXAS VICE PRESIDENT RESEARCH SERVICES 1155 UNION CIR #305250 DENTON TX 76203-5017					8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) USAF, AFRL DUNS 143574726 AF OFFICE OF SCIENTIFIC RESEARCH 875 NORTH RANDOLPH STREET, RM 3112 ARLINGTON VA 22203-1954 ERNA PETRICH 703-696-6563					10. SPONSOR/MONITOR'S ACRONYM(S)	
					11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Distribution A - Approved for public release						
13. SUPPLEMENTARY NOTES N/A						
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15. SUBJECT TERMS Additive manufacturing; metallic alloys; wear resistance						
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON	
a. REPORT	b. ABSTRACT	c. THIS PAGE			Thomas W. Scharf	
U	U	U	UU		19b. TELEPHONE NUMBER (Include area code) 1-940-891-6837	

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Q6. Program Officer

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Q7. Grant/Contract Number

AFOSR assigned control number. It must begin with "FA9550" or "F49620" or "FA2386"

FA9550-17-1-0345

Q8. Grant/Contract Title

The full title of the funded effort.

Fundamental Mechanistic Investigations of Additively Manufactured Multi-Phase Hybrid Materials

Q9. Principal Investigator Name

The full name of the principal investigator on the grant or contract.

Thomas Scharf

For an interim report, the reporting period start date is either start date of the grant, if this is the first report, or 1 day after the due date of the previous report. The end date is due date of this report.

Q22. Reporting Period Start Date

09-15-2019

Q23. Reporting Period End Date

09-14-2020

Q24. Report Abstract

In the Abstract section, please list any accomplishments that have been made since the last report submission (or since the beginning of the award if this is the first report). Please do not type "see report" here, include at least an abstract, 250 words or more, of the accomplishments mentioned in your report.

In recent years, additive manufacturing has gained increasing interest to produce novel near-net shape components. In contrast to conventional manufacturing techniques, like casting, we have determined that tailoring of microstructures along the build direction can achieve desired room and elevated temperature mechanical and wear properties for different alloys in the Ni-Al-Cr-C system. Specifically, we have explored laser additive manufacturing of novel hybrid materials with microstructures composed of solid solution strengthening and precipitation strengthening of a γ/γ' dendritic matrices, along with a distribution of reinforcing in situ formed hard ceramic (chromium carbides) and solid lubricant (graphite) phases. Such compositional modification of chromium and carbon were determined to drastically affect the corresponding phase morphology and properties, as determined by experimental and solution thermodynamic simulations. In addition, these laser deposited Ni-Al-Cr-C alloys could potentially be used for high temperature bearing houses that still require the need for high temperature solid lubrication at temperatures $>400^\circ\text{C}$, where current M50 steels exhibit oxidation issues leading to loss in rolling contact fatigue resistance. Mechanistic studies using surface and subsurface scanning and transmission electron microscopies in the wear surfaces revealed a combination of increased hardness/load-bearing and formation of tribochemical protective oxide glaze layers that were responsible for mitigating room and elevated temperature wear.

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Q16. Archival Publications (published) during reporting period:

1. T.B. Torgerson, S.A. Mantri, R. Banerjee, and T.W. Scharf, "Room and elevated temperature sliding wear behavior and mechanisms of additively manufactured novel precipitation strengthened metallic composites," Wear, Vol 426, Pages 942-951(2019).
2. T.B. Torgerson, M.S.K.K.Y. Nartu, S.A. Mantri, R. Banerjee, and T.W. Scharf *Laser Additive Manufacturing of Ni-Al-Cr-C Alloys: Microstructural Evolution during Solidification and Wear," submitted Additive Manufacturing (2020).

Q17. New discoveries, inventions, or patent disclosures to report for this period?
This question is required.

- No

Q18. Changes in research objectives (if any):

N/A

Q19. Change in AFOSR Program Officer, if any:

Dr. Jaimie Tiley to Dr. Martin Schmidt (acting)

Q20. Extensions granted or milestones slipped, if any:

No cost extension for period 9-15-2019 to 9-14-2020

Embedded Data:

<i>Date Stamp</i>	December 8, 2020
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