Plane:Bekerman, Christoph Ph.D.Project Tile:Effet of Convection on Columnar-to-Equiaxed Fransition in Alloy SublificationPortion Name:Poysical SciencesProgram/Docipline:Internation in Alloy SublificationProgram/Docipline:MTERIALS SCIENCE-Muterials seinceBrann Research Program Roke:NoManna Research Program Roke:NoSpace Biology Element:NoSpace Biology Element:NoSpace Biology Element:NoSpace Biology Element:NoSpace Biology Science:NoSpace Biology Science:Science:Space Biology Science:NoSpace Biology Science:NoSpace Biology Science:NoSpace Biology Science:No <th>Fiscal Year:</th> <th>FY 2015</th> <th>Task Last Updated:</th> <th>FY 12/26/2014</th>	Fiscal Year:	FY 2015	Task Last Updated:	FY 12/26/2014
Project Title: Elect of Convention on Columnar-to-Equitated Transition in Alloy Soldification Program Discipline: Program Discipline: NatTRIALS SCIENCE-Materials science Program Discipline: Tech Port: No Joint Agency Name: Tech Port: No Human Research Program Risks None International Materia State Biology Science: None International Materia Space Biology Science: None International Materia Space Biology Science: None International Materia Organization Stripp: None International Materia Organization Stripp: None International Materia Organization Stripp: UNIVERSTY Prove Science: Organization Stripp: Operational Stripp: International Materia Organization Stripp: Science:	PI Name:	Beckermann, Christoph Ph.D.	-	
Diskin Nume:Pysial ScienceProgram/Discipling- incomeMTERIALS SCIENCEMarcinal scienceJoint Agent XNat SCIENCEMarcinal scienceJoint Agent XNaHuma Research Program ReiseNaBanne Research Program ReiseNaSpace Biology EditationsNaSpace Biology EditationsNaSpace Biology Spacial CategoryNaSpace Biology Spacial CategoryNaPitenationNaPitenationNaPitenationNaSpace Biology Spacial CategoryNaPitenation <td>Project Title:</td> <td>Effect of Convection on Columnar-to-Equiaxed Transition</td> <td>in Alloy Solidification</td> <td></td>	Project Title:	Effect of Convection on Columnar-to-Equiaxed Transition	in Alloy Solidification	
Program/Disciplines- lement/Subdicplines- subdicplines- lement/Subdicplines- subdic	Division Name:	Physical Sciences		
Program/Shirpline- incomeMATERIALS SCIENCEMaterials scienceJoint Agenty Name:TechPore:NoHuman Research Program ElementsNoNoSpace Biology Stement:NoNoSpace Biology Stement:NoNoPlemati:NoNoSpace Biology Stement:NoNoPlemati:NoNo	Program/Discipline:			
Indrageny SummerTechny meNeHama Research Program KeenResSecondAnama Research Program KeenResSecondShare SummerResSecondShare SummerResSecondShare SummerResSecondShare SummerResSecondShare SummerResSecondParamerResSecondParamerResSecondParamerResSecondParamerResSecondParamerResSecondParamerResSecondParamerResSecondParamerResRes <t< td=""><td>Program/Discipline Element/Subdiscipline:</td><td>MATERIALS SCIENCEMaterials science</td><td></td><td></td></t<>	Program/Discipline Element/Subdiscipline:	MATERIALS SCIENCEMaterials science		
Hunan Research Program Risks None Space Biology Elements None Space Biology Schemets None Space Schemets None Space Schemets Space Schemets <	Joint Agency Name:		TechPort:	No
Hunan Research Program Risks: None Space Biology Clement: None Space Biology Coos-Element: None PI canal: Cooker/Cooker/Dooker PI canal: None Organization Type: University of Nowa PI Address 1: Opartment of Mechanical Engineering PI Address 1: Department of Mechanical Engineering PI Address 2: Otors Contro City: None Contro City: State: No of Oscillation / Soniglication / Soniglica	Human Research Program Elements:	None		
Space Biology Element:NoneSpace Biology Cross-Element:NoneSpace Biology Special Category:NoneP1 Email:Reckertific engineering atiowa eduFax: PY 319-335-5669P1 Organization Type:UNIVERSITYPhone:91 Carganization Type:Opartment of Mochanical Engineering91 Address 1:Opartment of Mochanical Engineering91 Address 2:Opartment of Mochanical Engineering91 Address 2:Opartment of Mochanical Engineering91 Address 2:Mutp?91 Veb Page:Mutp?/www.engineering atiowa.edu/91 Veb Page:Nave City91 Veb Page:State: I A91 Organization Xiao:State: I A9	Human Research Program Risks:	None		
Space Biology Special CategoryNoneSpace Biology Special CategoryNoneP1 EnanitScker(2engineering uioxy ach)Fax: PX3P335-5689P1 Granization Type:UNVERSTYPhone: 319335-5681Organization Type:Organization CategoryPhone: 319335-5681P1 Address 1:Organization CategoryPhone: 319335-5681P1 Address 1:Organization CategoryPhone: 319335-5681P1 Address 2:Organization CategoryPhone: 310424P1 Address 2:Organization CategoryPhone: 310424P1 Address 2:Organization CategoryPhone: 3262019P1 Address 2:Organization CategoryPhone: 326345P1 Address 2:Organization CategoryPhone: 326344038P1 Address 2:Organization CategoryPhone: 326344038P1 Address 2:Organization Phone: Address 2:Phone: 326344038P1 Address 2:Organization Phone: Address 2:Phone: 326344038P1 Address 2:Organization Phone: Address 2:Phone:	Space Biology Element:	None		
Space Biology Special CategoryNonePI Email:becker/filengineering uiowa.eduF.x: FY 319-335-5681PI Organization Type:UNIVERSITYPhone: 319-335-5681Organization Name:Department of Mechanical Engineering319-335-5681PI Address 1:Opantment of Mechanical EngineeringImpl/www.engineering uiowa.edu/PI Address 2:Phone: StateKaPI Web Page:Max CatyState: IAQi Dode:State: StateIAQi Dode:State: StateState: IAQi Dode:State: StateState: StatePi ofect Type:GroundSolicitation / Funding Source:2010 Materials Science Source:No. of PAB DescretImpl/www.engineering uiowa.edu/Impl/www.engineering uiowa.edu/Qi Dode:State: StateIAAddress 2:Congressional Distric:Impl/www.engineering uiowa.edu/No RightState: State: St	Space Biology Cross-Element Discipline:	None		
PI Enail:leckerikanninering uiowaeduFixF Y 319-335-569P1 Organization Type:VINYERSITYPhone319-335-561Organization Name:University of DowaSintersitySintersityP1 Address 1:Organization All Constrained EngineeringSintersitySintersityP1 Address 1:Organization Sume:SintersitySintersityP1 Address 1:Organization Sume:SintersitySintersityP1 Web Page:More CinySintersityImprovemention and SintersitySintersityDip Code:Organization Sume:SintersitySintersitySintersityOrgents:SintersitySintersitySintersitySintersityNo of Pathers:Organization Sume:SintersitySintersitySintersityNo of Pathers:SintersitySintersitySintersitySintersityNo	Space Biology Special Category:	None		
Pl Organization Type:UNIVERSITYPhone: 319-335-5681Organization Name:University of IowaPI Address 1:Department of Mechanical EngineeringPI Address 2:Ad2 Seamans CenterPI Web Page:Juttg/Vxww.engineering uiowa.edu/City:Iowa CityBow CityState:Ja Code:S242-1527Comments:Sourcessional Distrie:Project Type:Condand Contact ProvideNo. of PhotoSourcessional ScienceNo. of PhotoSourcessional Contact ProvideNo. of PhotoSourcessionNo. of PhotoSourcessionNo. of State: ScienceSourcessionNo. of Bachelor's Candidates:SourcessionCotact Monitor:Gordi, Sridhar Contact Phone:Sourcession:SourcessionFight Assignment:Sourcession SciencessionFight Assignment:Ion State Science SciencessionCotact Contact Procession:Sourcession Science Scie	PI Email:	becker@engineering.uiowa.edu	Fax:	FY 319-335-5669
Organization Name:University of lowaP1 Address 1:Department of Mechanical EngineeringP1 Address 2:2402 Seamans CenterP1 Web Page:http://www.engineering.uiowa.edu/City:Iowa CityState:IA Congressional District:22 Do Cole:5224-1527Comments:State:Project Type:GoudSolicitation / Funding: Source:0 Solicitation / Funding:010/1041No. of PAst Desc:10 Solicitation / Source:State:No. of Master's Candidates:20 Solicitation / Source:State:No. of Bachelor'sDegrees:No. of Master's Candidates:State:Source:State:Contact Monitor:State:Source:State:Fight Assignment:State:Fight Assignment:State:Contane (Institution):State:Source:State:Source:State:Source:State:Source:State:Source:State:Source:State:Source:State:No. of Master's Candidates:State:Source:State:State:State:State:State:State:State:S	PI Organization Type:	UNIVERSITY	Phone:	319-335-5681
PI Address 1:Department of Mechanical EngineeringPI Address 2:2402 Seamans CenterPI Web Page:http://www.engineering.uiowa.edu/City:lowa CityState:IAgo Code:52242-1527Congressional District:2 Do Comments:state:Solicitation / Funding:Project Type:GroundSolicitation / Funding:0 Solo / 2014End Date:0228/2019No. of Post Docs:1No. of Master' Degrees:No. of Post Docs:2No. of Master' Degrees:No. of Master's Candidates:Solicitation / Solicitation /	Organization Name:	University of Iowa		
PI Address 2:402 Seamans CenterPI Web Page:http://www.engineering uiowa.edu/City:lowa CitySure City:Sure City:Jap Code:S242-1527Congressional Distri:2Comments:sure City:Project Type:roundSolicitation / Funding Source:Solicitation / Funding Source:Solicitation / Europesure City:No. of Past Dese:0301/2014No. of Past Dese:1No. of PhD Candidates:0301/2014Source Standatdes:No. of Master' Degrees:No. of Master's Candidates:No. of Master' Degrees:No. of Master's Candidates:Minitori MasterSource Standators:Source Standators:Source Standators:Source Standators:Pight Program:State Induce Standators:Fight Assignment:NoTE: End date is now 2/28/2019 per NSC information (Ed., 12/1/15)Fight Assignment:NIX14D696Contact Tons:State Standators:Contact Tons:State Standators:Contact Tons:State State St	PI Address 1:	Department of Mechanical Engineering		
PlWeb Page:http://www.eniaecing.aiowa.edu/City:lowa CityState:IACip Code:S242-1527Congressional Distri:2Comments:Source:Solicitation / Funding:Solicitation / Funding:Solicitation / Funding:Project Type:GroundSolicitation / Funding:Solicitation / Funding:Solicitation / Funding:Sart Date:03/01/2014End Date:02/28/2019No. of Post Does:1No. of PhD Degrees:Solicitation / Funding:No. of PhD Candidates:2No. of Master's Degrees:Solicitation / BucherishNo. of Master's Candidates:Monitorian (Solitation / Contact Phone)Sol Solitation / Soli	PI Address 2:	2402 Seamans Center		
City:Iowa CityState:IAZip Code:52242-1527Congressional Distric:2Comments:	PI Web Page:	http://www.engineering.uiowa.edu/		
Zip Code:5242-1527Congressional District:2Comments:Project Type:GroundSolicitation / Funding Source:Nol Materials Science SNH10ZTT001NStart Date:03/01/2014End Date:0/28/2019No. of Pst Does:1No. of PhD Degrees:0/28/2019No. of PhD Candidates:2No. of Master' Degrees:-No. of Master's Candidates:2No. of Master' Degrees:-No. of Bachelor's Candidates:SightarNo. of Bachelor's Degrees:-No. of Bachelor's Candidates:Monitoring Cente:No. Sof Start Degrees:No. of Bachelor's Candidates:SightarSightar-Cottact Monitor:Gori, SridharContact Phone:Soft Start Degrees:Flight Arsignment:Soft End date is now 2/28/2019 per NSSC information (Ed., 12/1/15)Flight Assignment:NN14AD69GGrant/Contract No.:First Hand Start Degrees:Forformace Goal No.:Ferformace Coal Text:	City:	Iowa City	State:	IA
Comments:Project Type:GroundSolicitation / Funding Source:2010 Materials Science Source:Start Date:03/01/2014End Date:0/28/2019No. of Post Docs:1No. of PhD Degrees:No. of PhD Candidates:2No. of Master' Degrees:No. of Master's Candidates:INo. of Master' Degrees:No. of Bachelor's Degrees:Gorti, SridharKonter Young Cente:NASA MSFCContact Monitor:Gorti, SridharContact Phone:256 544-0158Contact Email:sridar.gorti@nasa.govSoft Station / Lucy / Soft Station / Lucy	Zip Code:	52242-1527	Congressional District:	2
Project Type:GroundSolicitation / Funding:Solin Materials Science Source:Start Date:0301/2014End Date:0/282/019No. of Post Docs:1No. of PhD Degrees:No. of PhD Candidates:2No. of Master' Degrees:No. of Master's Candidates:-No. of Master' Degrees:No. of Bachelor's Candidates:-Monitoring Center:NASK MSFCContact Monitor:Gorti, SridharContact Phone:Solitation / Solitation / Solit	Comments:			
Start Date:03/01/2014End Date:02/28/2019No. of Post Docs:1No. of PhD Degrees:Image: Constant Progrees:Image: Cons	Project Type:	Ground	Solicitation / Funding Source:	2010 Materials Science NNH10ZTT001N
No. of Pots Docs:1No. of PhD Degrees:No. of PhD Candidates:2No. of Master' Degrees:No. of Master's Candidates:So of Master's Candidates:So of Bachelor's Degrees:No. of Bachelor's Candidates:Monitoring Center:NASA MSFCContact Monitor:Gorti, SridharContact Phone:256 544-0158Contact Email:sridhar.gorti@nasa.govSo of So Stat-0158So of So Stat-0158Flight Program:NOTE: End date is now 2/28/2019 per NSSC information (L.) 1/1/15)So of So Stat-0158Key Personnel Changes/Previous P:So of So Stat-0158So of So Stat-0158Grant/Contract No.:NNX14AD69GSo NX14AD69GSo of So Stat-0158Performance Goal Text:So of So Stat-0158So of So Stat-0158	Start Date:	03/01/2014	End Date:	02/28/2019
No. of PhD Candidates:2No. of Master' Degrees:No. of Master's Candidates:No. of Master's Degrees:So of Bachelor's Degrees:No. of Bachelor's Candidates:Monitoring Center:NASA MSFCContact Monitor:Gorti, SridharContact Phone:256 544-0158Contact Email:sidhar.gorti@nasa.govSo of Sechelor's Candidates:So of Sechelor's Candidates:Flight Program:So TE: End date is now 2/28/2019 per NSSC information (Ed., 1/2/1/S)So of Sechelor's Candet Sechelor's Can	No. of Post Docs:	1	No. of PhD Degrees:	
No. of Master's Candidates:No. of Bachelor's Degrees:No. of Bachelor's Candidates:Monitoring Cente:NASA MSFCContact Monitor:Gorti, SridharContact Phone:256 544-0158Contact Email:sridhar.gorti@nasa.gov256 544-0158Flight Program:NOTE: End date is now 2/28/2019 per NSSC information (Ed., 12/1/15)StillerKey Personnel Changes/Previous PI:VOTE: End date is now 2/28/2019 per NSSC information (Ed., 12/1/15)StillerGrant/Contract No.:NNX14AD69GNNX14AD69GPerformance Goal No.:StillerStillerPerformance Goal Text:StillerStiller	No. of PhD Candidates:	2	No. of Master' Degrees:	
No. of Bachelor's Candidates: Monitoring Center: NASA MSFC Contact Monitor: Gorti, Sridhar Contact Phone: 256 544-0158 Contact Email: sridhar.gorti@nasa.gov Store Thom: Store Thom: Flight Program: NOTE: End date is now 2/28/2019 per NSSC information (Ed., 12/1/15) Store Thom: Store Thom: Key Personnel Changes/Previous PI: Store Thom: Store Thom: Store Thom: Store Thom: Grant/Contract No: NNX14AD69G Store Thom: Store Thom: Store Thom: Performance Goal No:: Store Thom: Store Thom: Store Thom: Store Thom:	No. of Master's Candidates:		No. of Bachelor's Degrees:	
Contact Monitor:Gorti, SridharContact Phone: 256 544-0158Contact Email:sridhar.gorti@nasa.govFight Program:NOTE: End date is now 2/28/2019 per NSSC information (Ed., 12/1/5)Key Personnel Changes/Previous PI:Set Set Set Set Set Set Set Set Set Set	No. of Bachelor's Candidates:		Monitoring Center:	NASA MSFC
Contact Email:sridhar.gorti@nasa.govFlight Program:Flight Assignment:NOTE: End date is now 2/28/2019 per NSSC information (Ed., 12/1/15)Key Personnel Changes/Previous PI:COl Name (Institution):Grant/Contract No.:NNX14AD69GPerformance Goal No.:Performance Goal Text:	Contact Monitor:	Gorti, Sridhar	Contact Phone:	256 544-0158
Flight Program: NOTE: End date is now 2/28/2019 per NSSC information (Ed., 12/1/15) Key Personnel Changes/Previous PI: COI Name (Institution): Grant/Contract No.: NNX14AD69G Performance Goal No.: Performance Goal Text:	Contact Email:	sridhar.gorti@nasa.gov		
Flight Assignment:NOTE: End date is now 2/28/2019 per NSSC information (Ed., 12/1/15)Key Personnel Changes/Previous PI:COI Name (Institution):Grant/Contract No.:NNX14AD69GPerformance Goal No.:Performance Goal Text:	Flight Program:			
Key Personnel Changes/Previous PI: COI Name (Institution): Grant/Contract No.: NNX14AD69G Performance Goal No.: Performance Goal Text:	Flight Assignment:	NOTE: End date is now 2/28/2019 per NSSC information	(Ed., 12/1/15)	
COI Name (Institution): Grant/Contract No.: NNX14AD69G Performance Goal No.: Performance Goal Text:	Key Personnel Changes/Previous PI:			
Grant/Contract No.: NNX14AD69G Performance Goal No.: Performance Goal Text:	COI Name (Institution):			
Performance Goal No.: Performance Goal Text:	Grant/Contract No.:	NNX14AD69G		
Performance Goal Text:	Performance Goal No.:			
	Performance Goal Text:			

Task Description:	ED. NOTE (7/14/2014): Project continues "Effect of Convection on Columnar-to-Equiaxed Transition in Alloy Solidification," grant #NNX10AV35G with period of performance 10/1/2010-2/28/2014. See that project for previous reporting. The project examines the mechanisms giving rise to the columnar-to-equiaxed grain structure transition (CET) during alloy solidification. On earth, experimental investigations of the CET are affected by thermosolutal buoyant convection and grain sedimentation/flotation, making it impossible to separate these effects from the effects of solidification shrinkage and diffusive processes in determining mechanisms for the CET. Long duration microgravity experiments suppress the convective effects and grain movement, thus isolating the shrinkage and diffusive phenomena. The project increases the base of knowledge relevant to the development of solidification microstructure/grain structure of metals and alloys. Therefore, this topic is of high interest from a fundamental science point of view and it is important to those engineers practicing casting and other solidification processes. Open scientific questions include the role played by melt convection, fragmentation of dendrite arms, and the transport of fragments and equiaxed crystals in the melt. The research utilizes computational models at three different length scales: phase-field, mesoscopic, and volume-averaged models. The phase-field model is needed to resolve the growth and transport processes at the scale of the microstructure, the mesoscopic model allows for simulations of entire experiments. The models help to define and interpret previous and future microgravity and ground-based experiments.
Rationale for HRP Directed Research	:
Research Impact/Earth Benefits:	The columnar-to-equiaxed transition (CET) in the grain structure of metal alloy castings has fascinated researchers in the solidification area for more than 50 years. The CET refers to the transition between the elongated grains in the outer portions of a casting and the more rounded grains in the center. Understanding this transition is fundamental to determining what type of grain structure forms in castings of most metal alloys (steel, aluminum, copper, etc.). Often, a fully equiaxed structure is preferred, but the fully columnar structures of many turbine blades are an important exception. In addition to its high practical significance, the CET represents a "holy grail" in the area of modeling and simulation of casting. This is because in order to realistically predict the CET, almost every physical phenomenon at every length scale must be taken into account simultaneously: heat transfer, solute transport, melt flow, and the transport of small dendrite fragments and equiaxed grains on the scale of the casting; the thermal/solutal/mechanical interactions between the growing grains/dendrites; and the nucleation of grains (especially in the presence of grain refiners) and fragmentation of existing dendrites. The research will not only provide an improved understanding of the CET, but also models and computer simulations of the grain structure formation in metal castings that can be used by industry to better understand and optimize their casting processes.
Task Progress:	Progress was made in all areas of the research on the columnar-to-equiaxed transition (CET) in alloy solidification: phase-field simulation, mesoscopic simulation, and macroscopic simulation. Three-dimensional phase-field simulations of alloy solidification are being conducted to study the dendrite evolution and fragmentation process on a microscopic (microstructure) scale. Fragmented dendrite sidebranches are believed to be a potent source of equiaxed grains. For this purpose, simulations are being conducted for columnar dendritic growth with an imposed temperature gradient and cooling rate. After a fully dendritic structure is obtained, the cooling rate is suddenly reduced. This leads to fragmentation of the dendrites at the junction between primary and secondary sidebranches. The fragmentation dynamics and rates are being studied as a function of the growth conditions. Considerable effort was devoted to parallelizing the code in order to allow for large scale simulations to be conducted. During the next project year, these simulations will be continued. A theory of the evolution of the specific interface area and fragmentation is being developed. Mesoscopic simulations of columnar and equiaxed solidification are being performed in order to investigate in detail the evolution of the grain structure on an intermediate scale. In this type of simulation, the evolution of the dendrite envelopes is tracked, while the solute field is calculated only in the extra-dendritic space between the envelopes. A three-dimensional computer code has been written and simulations have been performed to compare the predicted envelope shapes with available measurements. The next step is to include melt convection. Macroscopic simulations are being conducted to study the CET on the scale of an entire casting. A volume-averaged model is used for these simulations. The governing equations are solved using the public domain OpenFoam CFD software platform. The code was tested for columnar and equiaxed solidification without melt convec
Bibliography Type:	Description: (Last Updated: 12/04/2024)
Abstracts for Journals and Proceedings	Beckermann C. "Coarsening-Driven Dendrite Fragmentation in Directional Solidification." 4th International Conference on Advances in Solidification Processes, Old Windsor, United Kingdom, July 8-11, 2014. Conference Program. 4th International Conference on Advances in Solidification Processes, Old Windsor, United Kingdom, July 8-11, 2014. , Jul-2014
Abstracts for Journals and Proceedings	Beckermann C, Neumann-Heyme H. "Coarsening and Refinement Phenomena in Dendritic Solidification." Third International Symposium on Phase-Field Method – PFM 2014, Penn State University, State College, PA, August 26-29, 2014. Conference Program. Third International Symposium on Phase-Field Method – PFM 2014, Penn State University, State College, PA, August 26-29, 2014. , Aug-2014
Abstracts for Journals and Proceedings	Beckermann C, Neumann-Heyme H. "Concurrent Growth and Coarsening of Dendrites." Frontiers in Solidification Research, DLR, Cologne, Germany, September 2014. Conference Proceedings. Frontiers in Solidification Research, DLR, Cologne, Germany, September 2014. , Sep-2014
Articles in Peer-reviewed Journals	Yamaguchi M, Beckermann C. "Direct numerical simulation of solid deformation during dendritic solidification." JOM. 2014 Aug;66(8):1431-8. <u>http://dx.doi.org/10.1007/s11837-014-1001-4</u> , Aug-2014

Awards	Neumann-Heyme H, Eckert K, Beckermann C. "Best Poster Award for 'Coarsening-Driven Dendrite Fragmentation in Directional Solidification,' 4th International Conference on Advances in Solidification Processes, Old Windsor, United Kingdom, July 8-11, 2014." Jul-2014
Papers from Meeting Proceedings	 Souhar Y, De Felice VF, Založnik M, Combeau H, Beckermann C. "Three-Dimensional Mesoscopic Modeling of Equiaxed Dendritic Solidification in a Binary Alloy." 4th International Conference on Advances in Solidification Processes, Old Windsor, United Kingdom, July 8-11, 2014. 4th International Conference on Advances in Solidification Processes, Old Windsor, United Kingdom, July 8-11, 2014. Proceedings, In Press, as of December 2014. , Dec-2014