COVER SHEET FOR GRANT PROPOSALS

State Board of Education

SBOE PROPOSAL NUMBER: (to be assigned by SBOE)	AMOUNT REQUESTED: $700,000

TITLE OF PROPOSED PROJECT: Wide Band Gap and Harsh Environment Semiconductor RD&D Capability

SPECIFIC PROJECT FOCUS:

Wide band gap and harsh environment semiconductors are currently on the cutting edge of research in materials science, solid state physics, and electrical engineering fields around the globe. These materials hold several key scientific and engineering advantages over existing semiconductor material systems. Able to operate with higher efficiencies, higher currents, and higher outputs, these materials hold a strategic focus in energy harvesting and green energy solutions. The proposed effort leverages several strategic components at the RISE Complex and aims to develop a focused research, development and demonstration capability in the growth and characterization of functionalized wide band gap and harsh environment semiconductors. Leveraging significant high tech startup interest, this proposal will bring numerous new jobs and economic growth areas to Idaho and provide the ability to grow as an industry center. The total amount requested is $700,000 for a one-year period of performance.

PROJECT START DATE: 7/1/2015	PROJECT END DATE: 6/31/2016
NAME OF INSTITUTION: Idaho State University	DEPARTMENT: RISE Complex, Office of Research and Economic Development
ADDRESS: 1999 Alvin Ricken Dr. Pocatello ID 83201	
E-MAIL ADDRESS: burgeric@isu.edu burgeric@isu.edu, resdev@isu.edu	PHONE NUMBER: 208-282-2220

	NAME:	TITLE:	SIGNATURE:
PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR	Dr. Eric Burgett	Director	
CO-PRINCIPAL INVESTIGATOR	Dr. Chris McGrath, Dr. Tony Hill	Research Engineer	

NAME OF PARTNERING COMPANY: NuMat Inc., E. J. Proprietary Properties	COMPANY REPRESENTATIVE NAME: Mr. Harry J. Nause Mr. Jeff Short

	NAME:	SIGNATURE:
Idaho State University	Cornelis Van Der Schyf	
NuMat Inc	Harry J. Nause Jr.	
EJ Proprietary Properties	Jeff Short	

SUMMARY PROPOSAL BUDGET

Name of Institution: Idaho State University

Name of Project Director: Dr. Eric Burgett

A. PERSONNEL COST (Faculty, Staff, Visiting Professors, Post-Doctoral Associates, Graduate/Undergraduate Students, Other)

Name/ Title	Salary/Rate of Pay	Fringe	Dollar Amount Requested

% OF TOTAL BUDGET:		SUBTOTAL:	

B. EQUIPMENT: (List each item with a cost in excess of $1000.00.)

Item/Description	Dollar Amount Requested
Zinc Oxide MOCVD Pilot scale unit	$135,000
High Pressure Crystal Growth Furnace	$250,000
Hot Isostatic Press	$35,000
TGA-GC-ICP-MS	$240,000
SUBTOTAL:	$660,000

G. TRAVEL:

Dates of Travel (from/to)	No. of Persons	Total Days	Transportation	Lodging	Per Diem	Dollar Amount Requested
					SUBTOTAL:	$0

H. Participant Support Costs:

	Dollar Amount Requested
1. Stipends	
4. Other	
SUBTOTAL:	$0

I. Other Direct Costs:	Dollar Amount Requested
1. Materials and Supplies	
2. Publication Costs/Page Charges	$0
3. Consultant Services (Include Travel Expenses)	
4. Computer Services	
5. Subcontracts	
6. Other (specify nature & breakdown if over $1000) Installation Shipping	$25,000 $15,000
SUBTOTAL:	$40,000
J. Total Costs: (Add subtotals, sections A through I) TOTAL:	$700,000
K. Amount Requested: TOTAL:	$700,000
Project Director's Signature:	Date:

INSTITUTIONAL AND OTHER SECTOR SUPPORT

(add additional pages as necessary)

A. INSTITUTIONAL / OTHER SECTOR DOLLARS

Source / Description	Amount
Industrial support for personnel and engineers: NuMat Inc.	$120,000/yr
Industrial support EJPP	$125,000/yr

B. FACULTY / STAFF POSITIONS

Description	
Crystal Growth Engineer (Federal Grants)	$35,000 + fringe + overhead

C. CAPITAL EQUIPMENT

Description
See facilities and equipment appendix A.

D. FACILITIES & INSTRUMENTATION (Description)

Clean room space, semiconductor characterization tools, semiconductor fabrication equipment

1. **University:** Idaho State University

2. **PI:** Dr. Eric Burgett, Co-PIs: Dr. Chris McGrath, Dr. Tony Hill

3. **Project objective and total amount requested:** Wide band gap and harsh environment semiconductors are currently on the cutting edge of research in materials science, solid state physics, and electrical engineering fields around the globe. These materials hold several key scientific and engineering advantages over existing semiconductor material systems. Able to operate with higher efficiencies, higher currents, and higher outputs, these materials hold a strategic focus in energy harvesting and green energy solutions. The proposed effort leverages several strategic capabilities at the RISE Complex and aims to develop a focused research, development and demonstration capability in the growth and characterization of functionalized wide band gap and harsh environment semiconductors. Leveraging significant high tech startup interest, this proposal will bring numerous new jobs and economic growth areas to Idaho and provide the ability to grow as an industry center. The total amount requested is $700,000 for a one-year period of performance.

Nowhere in the United States can such a comprehensive capability set be found. This effort brings together all stages of advanced wide band gap semiconductor device fabrication as well as extreme environment semiconductors with a special emphasis on the fundamental building blocks of semiconductor growth which are not found anywhere in a high tech R&D environment. The proposed effort will add capabilities to meet the growing needs for bulk wide band gap semiconductor materials as well as epitaxial films of novel band gap engineered semiconductor films and establish a demonstration pilot scale production capability. Numerous articles point to the field of wide band gap semiconductors and extreme environment materials as the new frontier for materials science and semiconductor physics[1,2,3]. The establishment of this

capability, co-located with other assets at the RISE Complex, situates southeastern Idaho as becoming the nexus of research in this hot field[4].

Idaho State University and Dr. Burgett have developed several key pieces of intellectual property surrounding this proposal. These key advances allow for the growth of some of the world's largest and highest purity harsh environment and wide band gap semiconductor materials. Focused on bulk material growth, both n and p type semiconductor materials can be grown in formats of up to 8" diameters with the infrastructure being proposed. Dr. Burgett has pioneered the growth techniques as well as the dopant profiles to achieve long lasting, high quality n and p type wide band gap and harsh environment semiconductor materials. These bulk substrates and semiconductor materials lay the groundwork for large functionalized devices including high efficiency solar cells, high power electronics, radiation detectors, and high efficiency LEDs. A second focus is on epitaxial growth of high quality layered semiconductors including p type ZnO, a proprietary technology which has surpassed the world's capability of high quality p-type ZnO. These epitaxial growth capabilities allow for functionalized device preparation including band gap engineered and tuned LEDs, variable turn on power electronics, enhanced efficiency solar cells, as well as transparent displays and advanced Heads Up Display (HUD) technologies. Lastly, a high quality isotopic QA semiconductor characterization capability is being proposed to be added. This will allow for a high pedigree of material to be grown through feedstock purification and verification as well as quantification of impact of impurities on the semiconductor materials. With resolutions approaching ppq, this needed capability will provide the high fidelity information needed by industry collaborators moving these products into the commercial marketplace.

This added capability would add a much-needed capacity to the R&D to the RISE

Complex and provide a demonstration pilot scale production line to foster commercialization of the IP developed at ISU. There today exists a need to provide these resources on a commercial scale. ISU receives commercial production requests for these high quality, wide band gap and harsh environment semiconductors frequently. The existing toolset at the RISE Complex is already committed to active R&D efforts. This infrastructure will allow commercial businesses to relocate to Pocatello and work in concert with the research team at the RISE Complex to commercialize the IP being developed or existing IP at ISU. This project will have an immediate impact on the local economy moving more high paying jobs to the area and establishing ISU as the center for the wide band gap and harsh environment semiconductor boom.

4. **Resource commitment:** This proposed project leverages several strategic investments, which have been made at the RISE Complex. First, the RISE Complex has established a fully functioning semiconductor processing capability from crystal growth, to wafer preparation and fabrication, to epitaxial growth, lithography, etching, contacting, and packaging. This all told has been an investment of well over 2 million dollars obtained through federal funding sources. To complement these capabilities, a focused effort is desired to build on existing intellectual property and scale up the wide band gap semiconductor capability to make it viable to commercial interests. Existing capabilities are at capacity or overcommitted and this proposed effort will synergistically grow ISU's capability and establish itself as the center of wide band gap semiconductor materials RD&D and establish a pilot scale commercialization capability.

5. **Specific project plan:** The project is slated to begin on July 1st, 2015. The project is predominantly focused around the acquisition, commissioning, and demonstration of four major pieces of research infrastructure. In the first quarter, the capital equipment purchases will be made. Due to the long lead times for the fabrication of several of the components of the systems,

the next six months will be devoted to acquisition and installation of the systems. The last three months will be devoted to demonstration of the growth capabilities of the systems. Proposals supporting this equipment to the DOD, DOE and other federal agencies will begin upon successful award of this project. The added RD&D program along with commercialization proposals will continue for the indefinite future.

6. **Potential economic impact:** This project stands to make a significant economic impact. Adding these proposed capabilities will bring a minimum of two companies to the Pocatello area and establish the Southeast Idaho region as a focus for wide band gap and extreme environment semiconductor growth and development. By moving these companies to Idaho, in excess of $20 million in gross revenue could be brought into the southeastern Idaho region. The two partner companies will add a number of jobs in the first year alone. Building in future expansion and commercialization, the number of high paying tech jobs will balloon as these companies establish themselves in southeastern Idaho. In numerous other reports, the market for these wide band gap semiconductor capabilities place the market size significantly larger. "*A new report from industry analyst firm NanoMarkets says that Zinc Oxide (ZnO) is emerging as an important electronics material, with sales of conductive coatings, electrode materials, and electronic devices using ZnO more than tripling to* ***$1.3 billion by 2015*** *and going on to reach* ***$2.3 billion by 2017****."* (Nanomarkets *"Zinc Oxide Markets, 2010 and Beyond"*). Much of that research development and deployment could be centered here in southeastern Idaho. The intellectual property developed by Dr. Burgett and the researchers at the RISE Complex make this possible. In the first two years, the two companies and ISU will add approximately $500,000 in wages to the local economy. Bannock Development Corporation (BDC) estimates that $1.00 in direct wages generates $2.00 in the local economy, thereby addition another $500,000 to the local

economy. Further, revenue generated from manufacturing has a multiplying effect of 2.3, according to BDC. Within five years of establishment, the facility could generate $10,000,000, resulting in a local economic impact of $23,000,000.

7. **Criteria for measuring success:** The project's success will be measured in two primary methods. The first is the added number of R&D proposals and funding which is awarded as a result of this effort. It is envisioned this capability will result in at least two additional large R&D proposals to federal agencies per quarter, of which one per quarter will include industry partners for commercialization of products developed within this proposal. The second method for quantifying success will be the industry collaborations, which are started due to these enhanced capabilities which are being proposed herein. This project directly aims to commercialize, with two high tech companies, the recent advances in wide band gap and extreme environment semiconductors developed at Idaho State University by Dr. Burgett. A measure of this commercialization success is the number of new employees, which are hired by the respective companies to assist in the fabrication and final delivery of new products to the market. A second measure of success will be the amount of royalties and licensing fees brought into ISU as a result of these efforts. The proposed commitments of the two collaborator companies are stated in their supporting documentation supplied as an appendix to this proposal.

8. **Budget:** See Above.

9. **Budget justification:** This project will add a large, high pressure, proprietary design semiconductor growth furnace for growing large-scale bulk harsh environment and wide band gap semiconductor wafers. This furnace will complement existing crystal growth furnaces at the RISE Complex, which are already fully committed with R&D from DOE, DOD and private sector research partners. The proposed crystal furnace meets a growing need to supply R&D

capabilities as well as deployment capabilities of industry partners who want pilot scale production capabilities. The second major addition is a pilot scale MOCVD tool devoted specifically to ZnO growth. The tool will be modified with several enhancements designed at the RISE Complex by Dr. Burgett's team making this tool a cutting edge RD&D tool. This tool complements the existing wide band gap semiconductor growth capabilities including a GaN MOCVD tool. This pilot scale tool will meet the current and future growth needs of the RISE Complex R&D mission as well as the collaborative commercialization effort of NuMat and EJ Proprietary Properties. A Hot Isostatic Press (HIP) system is proposed to support the increased throughput of the crystal furnaces. This tool is needed to prepare the feedstock for the proposed crystal furnaces for crystal growth. Lastly, a pair of semiconductor grade characterization tools is proposed to assist in the quantification and certification of semiconductor materials grown under this focused project's effort. The tools, a thermo-gravimetric gas chromatograph mass spectrometer is coupled to an inductively coupled mass spectrometer with a collision cell and semiconductor grade characterization and analysis capabilities to quantify ppq level impurities that must be quantified for precise semiconductor growth. All of these tools work synergistically to produce a focused RD&D capability in wide band gap and extreme environment semiconductors.

10. **Institutional commitment:** This proposal is being submitted by the director of the ISU RISE Complex. This project is a strategic focus of the RISE Complex. The RISE Complex is committed to the success of this project. For every engineer hired to support this effort by the industry partners, the RISE Complex will hire a matching number of engineers. This will allow a multi-disciplinary combined cohort of engineers forming a public-private partnership which is united in a unified R&D mission to be trained by Dr. Burgett. The team of Co-PIs will also

assist in the training of engineers and technicians. This team will form the basis of establishing a center of excellence and nexus of R&D as well as a demonstration pilot scale production here in southeastern Idaho.

Also provided in a supplemental letter attached as an appendix to this proposal is a letter of commitment from the VP of Research of Idaho State University, Dr. Cornelis Van der Schyf. This effort has the support of the VP of research and the administration of the university.

11. **Additional institutional and other sector support:** The RISE Complex and Idaho State University fully support this proposed effort. The extreme semiconductor and wide band gap material growth capabilities are a core strategic direction of the RISE Complex. Available to this project are a host of other supplemental characterization, preparation, fabrication and testing capabilities. This project will be housed in several of the RISE Complex clean rooms. The external partners are proposing several hundred thousand in funding. NuMat is committing to funding several crystal growth and MOCVD engineers in addition to their existing R&D team. ISU will commit a matching number of crystal growth engineers and MOCVD engineers to the team through federal funding sources. They are committing a significant amount of intellectual property to be used in concert with ISU IP in mutual R&D as well as a commitment to pay for all applicable patenting costs for protecting the ISU IP and jointly developed IP. NuMat is also committed to a royalty and licensing fee to Idaho State University for work supported by this project. NuMat already has a contract being negotiated with ISU. EJPP is committing to patent all applicable IP on extreme environment semiconductors developed by Idaho State University as well as all jointly developed IP. These real costs will be quantified as measurable success for this project. This effort will add capabilities which will be available to all universities in Idaho with the establishment of a joint research proposal through Idaho State University.

Appendix A:

Facilities and Equipment

The RISE Complex is a 218,000 square foot research facility with over 100,000 square feet of clean room space. This project will utilize three primary areas in the RISE Complex, the main crystal growth lab will house the crystal growth furnace and wide band gap semiconductor MOCVD tool, the materials prep area will house the HIP furnace, the analytics lab will house TGA-GC-ICP-MS tool. All of these tools are centrally located around other tools of like functionality for maximum usefulness and project integration.

Supporting the wide band gap semiconductor MOCVD tool and the bulk high pressure crystal growth furnace are:

- Extreme environment MOCVD tool Veeco/Emcore D160
- III-V and III-N wide band gap MOCVD tool Veeco/Emcore D180
- Extreme environment bulk crystal furnace (Custom fabricated to spec)
- Fluidized bed reactor for feedstock purification (Custom fabricated to spec)
- Controlled atmosphere glove boxes for feedstock preparation
- Controlled atmosphere glove boxes for chemistry synthesis
- Diamond wire substrate wafering saw
- Substrate lapping machine
- Substrate polishing machine
- Thermoset mounting machine
- Vacuum glove box for thermal annealing and controlled atmosphere post growth

annealing

- Cold sintering die
- Hot sintering furnace
- Annealing furnaces

Supporting the TGA-GC-ICP-MS there is a host of analytical semiconductor analysis tools

- 8” focused ion beam microscope with SIMS and Pt deposition
- 8” Dual Beam microscope with EDAX, OmniProbe nanomanipulator, Pt and W deposition
- FEI ESEM FEG with EDAX, EBSD, BSED, SED, and EBIC
- AMRAY analytical SEM
- X-ray Microscope
- Bruker-Siemens D5000 Diffraktometer Single Crystal XRD
- Phillips CM-10 TEM
- Joel 2000FX STEM
- Oxford ICP-AES

Supporting the analysis of semiconductor materials

- Variable wavelength excimer laser driven Photoluminescent spectroscopy system
- Four point probe
- Manual probe station
- Automated probe station
- Hall measurement system
- Customized Keithley 4200 SCS series system
- DLTS

- O-DLTS
- EBIC

Supporting the semiconductor fabrication capability

- Oxford plasmalab 80 dry reactive ion etcher
- Spin coaters
- E-beam lithography system
- Thermal PVD system
- E-beam PVD system
- Jipelec Jetfast 100 RTA system
- Phoenix wet bench
- Wire bonder

Supporting Radiation Detection Capabilities

- Scintillator linearity light yield neutron and gamma ray calibration capability
- Ultra-fast MCP light collection system
- 16 detector BGO suppressed HPGe detector array
- 32 detector neutron spectrometer array
- Calibrated large volume scintillator detector test stand
- Homeland Security Passive Detector Calibration facility
- Alpha spectrometer system

Supporting harsh environment semiconductor capability

- 75 kW RF variable frequency field generator
- Ultra-high temperature test furnace
- 10 MeV tandem pelletron ion accelerator

- 10 MeV electron accelerator
- High pressure hydraulic testing system

Appendix B:

Biographical Sketches and Individual Support

Biographical Sketch

Dr. Eric A. Burgett

Department of Nuclear Engineering, Idaho State University, Pocatello, ID 83209

(208) 282-2220. burgeric@isu.edi

PROFESSIONAL PREPARATION

Georgia Institute of Technology	Nuclear and Radiological Engineering	B.S. 2005
Georgia Institute of Technology	Nuclear Engineering	M.S. 2008
Georgia Institute of Technology	Nuclear Engineering	Ph.D. 2010

APPOINTMENS

2010 – Present Assistant Professor, Department of Nuclear Engineering, Idaho State University
2010 – Present Research Engineer, Idaho National Laboratory
2008 – 2010 Research Engineer, Nuclear Engineering, Georgia Institute of Technology
2005 – 2008 Health Physicist, Georgia Institute of Technology

PRODUCTS

E. Burgett, R. Howell, N. Hertel, B. Wiegel, H. Schumacher, "Calibration of a Bonner Sphere Extension (BSE) For High-Energy Neutron Spectrometry" 2010 *Radiation Measurements*, Volume 45 *Issue 1o.*

E. Burgett, N. Hertel, A. Melton, I. Ferguson, C. Summers, "Thermal Neutron Scintillators Grown by MOVCD"AIP Conference Proceedings March 2009, *Volume 1099, In Press.*

E. Burgett, A. Melton, M. Jamil, T. Zaidi, N. Hertel, and I. Ferguson, "GaN as a Neutron Detection Material"Proceedings of the IEEE SouteastCon 2010. *In Press.*

E. Burgett, N. Hertel, T. Blue, J. Chenkovich. "Neutron Spectral Measurement of the Ohio State Research Reactor Pneumatic Tube" *Journal of* Radioanalytical and *Nuclear Chemistry, Volume 282, Number 1.*

E. Burgett, R. Howell, N. Hertel, S.Kry, Z. Wang. "Measurement of High-Energy Neutron Spectra with a Bonner Spere Extension (BSE) System" May 2009 *Nuclear Techology. Vol 116.*

E. Burgett, R. Howell, N. Hertel. "Cross Section and Angular Dependence of a Bonner Sphere Extension", May 2009 *IEEE* Transactions on Nuclear Science, *Vol 56 Issue 53.*

Z. Wang, R. Howell, **E. Burgett**, S. Kry, N Hertel, M. Salehpour. "Determination of Working Response Functions for Indium Activation Foils Up to 800 MeV in an Au-In-BSE System" *Rad Prot. Dosim.*

Z. Wang, S. Kry, **E. Burgett**, R. Howell, R. Tailor, J. Oliver, D. Followill, A. Smith, M. Salehpour. "Measurement of Neutron Spectrum and Ambient Dose Equivalent Around a Mini-Phantom at a Proton Therapy Facility" June 2008 *Med. Phys.*, Vol 35 Issue 65, pages 2962-2982.

Z. Wang, J.D. Hutchinson, N. Hertel, **E. Burgett** and R.M. Howell, "Study of a Gold –Foil Based Multisphere Neutron Spectrometer", 2008 *Radiat. Protect. Dosim.* Vol 128 Issue 3, pages 289-293.

R. Karam, D. Blaylock, **E. Burgett**, N. Hertel. "High Temperature Helium-Cooled Fast Reactor (HTHFR)" *Energy Conversion* and *Management*, Vol 47 Issue 17, 2006, pages 2794-2800.

Current Support

Battery Recharging Station using NanoRad Power Pack; Funding source: Defense Advanced Research Projects Agency; Project location: Idaho State University ; Funding period: April 2015 – March 2018; Amount of award: $3,000,000; Person-months per year to be devoted to the project: 2

Supporting ScanTech Sciences; Funding Source: ScanTech Identification Beam Systems LLC; Project location: Idaho State University; Funding Period: April 2015 – December 2016; Amount of Award: $250,000; Person-months per year to be devoted to the project: 0

Supporting ScanTech Sciences; Source: ScanTech Identification Beam Systems LLC; Project location: Idaho State University; Funding Period: April 2015 – December 2016; Amount of Award: $1,000,000; Person-months per year to be devoted to the project: 0

Creation of Analytical Facility to Support Idaho High Technology Companies; Funding Source: US Department of Commerce; Project location: Idaho State University; Funding Period: June 2014 – May 2015; Amount of Award: $300,000; Person-months per year to be devoted to the project: 0 (no salary support)

Joint Appointment; Funding Source: Battelle Energy Alliance, LLC; Project location: Idaho State University; Funding Period: July 2014 – June 2015; Person-months per year to be devoted to the project: 6

NanoRad Power Pack; Funding Source: US Department of Defense; Project location: Idaho State University; Funding Period: Feb 2014 – Jan 2018; Amount of Award: $4,191,248; Person-months per year to be devoted to the project: 3

University Support for the Fission Time Projection Chamber Project; Funding Source: Battelle Energy Alliance, LLC; Project location: Idaho State University; Funding Period: Jun 2012 – Sept 2015; Amount of Award: $800,000; Person-months per year to be devoted to the project: 0

University Support for Fuels Research; Funding Source: Battelle Energy Alliance, LLC; Project location: Idaho State University; Funding Period: Sept 2013 – Sept 2015; Amount of Award: $100,000; Person-months per year to be devoted to the project: 0

Pending Support

Ventilation Upgrade at RISE Complex; Funding Source: Department of Energy; Project location: Idaho State University; Funding Period: April 2015 – Oct 2015; Amount of Award: $250,000; Person-months per year to be devoted to the project: 0

Biographical Sketch

CHRISTOPHER A. MGRATH

Department of Research & Innovation in Science & Engineering, Idaho State University, Pocatello, ID 83209-8007

(208) 282-1162, mcgrchri@isu.edu

PROFESSIONAL PREPARATION

Gannon University	Mathematics	B.S. 1991
University of Kentucky	Chemistry	Ph.D. 1996
Lawrence Berkeley National Lab	Heavy Element Chemistry	Postdoc, 1996-98
Lawrence Livermore National Lab	Nuclear Physics	Postdoc, 1998-99

APPOINTMENTS

2013-present Nuclear Chemical Engineer, Department of Research & Innovation Science & Engineering, Idaho State University

1999-2013 Research Scientist/Radiochemistry Lead, Idaho National Laboratory

PRODUCTS

McGrath, C., Robinson, T., Mann, N., Oertel, C., and Watrous, M. High-Pressure Marinelli for Counting Low-Activity Compressed Gas Samples. *Journal of Radioanalytical and Nuclear Chemistry*, In Press.

McGrath, C., Carney, K. P., Finck, M. R., Martin, L. R., and Lewis, R. R. The development of radioactive glass surrogates for fallout debris. *Journal of Radioanalytical and Nuclear Chemistry*, DOI 10,1007/s10967-013-2800-8.

McGrath, C., Houghton, T. P., Pfeiffer, J. K., and Hague, R. K. Xe-135 production from Cf-252. *Journal of Radioanalytical and Nuclear Chemistry*, 296, 893, (2013).

McGrath, C., Carney, K., Finck, M., Brush, B., Jansen, D., Dry, D., Brooks, G., and Chamberlain, D. The development of radioactive sample surrogates for training and exercises. *Journal of Radioanalytical and Nuclear Chemistry*, 296, 769, (2013).

McGrath C., Carney, K. P., Horkley, J.J., Edwards, A.J., Davies, J. E., Knighton, G. C., Sommers, J. D., and Giglio, J. J. Advancement of isotope separation for the production of reference standards. *Journal of Radioanalytical and Nuclear Chemistry*, 296, 383, (2013).

Youinou, G., Palmiotti, G., **McGrath, C**., Imel, G., Paul, M., Pardo, R., Kondev, F., and Salvatores, M. "MANTRA" An Integral Reactor Physics Experiment of Infer Acitnide Capture Cross-sections from Thorium to Californium with Accelerator Mass Spectrometry. *Journal of the Korean Physical Society*, 59, 1940, (2011)

McGrath, C., and Gehrke, R. J. A Comparison Of Pulser-based Analog and Digital Spectrometers. *Journal of Radioanalytical and Nuclear Chemistry*, 276, 669, (2008).

Baker, J.D., **McGrath, C.**, Hill, T. S., Reifarth, R., and Tovesson, F. Actinide Targets For Neutron Cross Section Measurements. *Journal of Radioanalytical and Nuclear Chemistry*, 276, 555, (2008).

McGrath, C., Villani, M. F., Garrett, P. E., and Yates, S. W. Gamma-Gamma Coincidence Measurements Following Inelastic Neutron Scattering. *Nucl. Instr. and Meth*., A421, P. 458 (1999).

McGrath, C., Villani, M. F., Garrett, P. E., and Yates, S. W. Gamma-Gamma Coincidence Measurements Following Inelastic Neutron Scattering. *Nucl. Instr. and Meth*., A421, P. 458 (1999).

McGrath, C., Villani, M. F., DiPrete, D. P., Garrett, P. E., Yeh, M., and Yates, S. W. Spectroscopic Studies of the Stable Xenon Nuclei from (n,n' □□) Coincidence Me Neutrons, *Proc.9th Intern. Symposium on Capture Gamma-Ray Spectroscopy and Related Topics, Budapest, Hungary*, October 1996, G. L. Molnar, T. Belgya, Zs. Revay, Eds., Vol.1, p.228 (1997).

Current Support

None

Pending Support

Transuranic Target Production
Funding Source: Department of Energy
Project location: Idaho State University
Funding Period: Oct 2015 – Sept 2018
Amount of Award: $820,393
Person-months per year to be devoted to the project: 6

Transuranic Detection Methodologies
Funding Source: Department of Energy
Project location: Idaho State University
Funding Period: Oct 2015 – Sept 2018
Amount of Award: $804,003
Person-months per year to be devoted to the project: 6

Biographical Sketch

TONY S. HILL

Department of Research & Innovation in Science & Engineering, Idaho State University, Pocatello, ID 83209-8007 (208) 282-1154, hilltony@isu.edu

PROFESSIONAL PREPARATION

Abilene Christian University	Physics	B.S. 1991
Iowa State University	Physics	M.S. 1993
Iowa State University	Physics	Ph.D. 1996

APPOINTMENTS

2014 – present Senior Researcher, RISE Complex, Idaho State University
2009 – 2014 Group Leader, Nuclear Physics and Instrumentation, INL
2007 – 2009 Research Team Leader, LANSCE Neutron Science Group, LANL
2003 – 2007 Technical Staff Member, LANSCE Neutron Science Group, LANL
2000 – 2003 Technical Staff Member, Computational Nuclear Physics, LLNL
1996 – 2000 Research Associate, Department of Physics, University of California at Santa Barbara, stationed at Cornell

PRODUCTS

NIFFTE Collaboration (M. Heffner, et. al.) A Time Projection Chamber for High Accuracy and Precision Fission Cross Section Measurements, NIMA 759 (2014) 50.

NIFFTE Collaboration (J. Ruz, et. al.) The NIFFTE Project, Journal of Instrumentation, 174-0221 8 C12018 (2013).

Hill, T.S., Tovesson, F., and Laptev, A.B., Fast Neutron-Induced Actinide Fission Measurements Relevant to Transmutation Studies, *Transactions of the American Nuclear Society*, 104 (2011) 679-680.

Hill, T.S., Tovesson, F., and Laptev, F., Fission Cross Section Measurements of Actinides at LANSCE, *Journal of the Korean Physical Society* Vol 59, Special Issue 2, pages 1400-1403, Part 3 (2011).

Hill, T.S., and Tovesson, F., Cross Sections for 239Pu(n,f) and 241Pu(n,f) in the range En=0.01 eV to 200 MeV, *Nucl. Sci. Eng*. 165, 224 (2010).

Tovesson, F., and **Hill, T.S.**, Sub-threshold Fission Cross Section of 237Np, *Nuclear Science and Engineering* 159, 83 (2008).

Baker, J.D., McGrath, C.A., and **Hill, T.S.** et al., Actinide Targets for Neutron Cross Section Measurements, *Journal of Radioanalytical and Nuclear Chemistry* Vol. 276, No.2 (2008) 555-560.

Tovesson, F., and **Hill, T.S.**, Fission Cross-Section Measurement Programme at LANSCE, *Actinide and Fission Product Partitioning and Transmutation* (2007) 553.

Tovesson, F., and **Hill, T.S.**, Neutron Induced Fission Cross Section of 237Np from 100 keV to 200 MeV, *Phys. Rev. C75* (2007) 034610.

Tovesson, F., **Hill, T.S.**, Hanson, K.M., Talou, P., Kawano, T., Haight, R.C., and Bonneau, L., Covariance matrix for a relative 237Np(n,f) cross section measurement, *LA-UR-06-7318*, (2006).

SYNERGUSTIC ACTIVITIES (5 examples)

a) Group Leader - Nuclear Physics and Instrumentation, INL
b) Project Manager/PI - Advanced In-Situ Measurements at TREAT, INL/LDRD
c) Project Manager/PI - Separate Effects Fuels Development Capability, INL/LDRD
d) Project Manager/PI - Advanced Elastic/Inelastic Nuclear Data Project DOE/NE NEUP
e) National Technical Director - Transmutation Technology, DOE/NE-FCRD

Current Support

None

Pending Support

Expanded Radiological Material Handling and Processing Capabilities for ISU Reactor
Program Funding Source: Department of Energy
Project location: Idaho State University
Funding Period: Oct 2015 – Sept 2016
Amount of Award: $113,293
Person-months per year to be devoted to the project: 0

Appendix C

Other

Letters of Commitment

Idaho State
UNIVERSITY

Office for Research
921 South 8th Avenue, Stop 8130 • Pocatello, Idaho 83209-8130

From: Cornelis J. Van der Schyf
To: IGEM Committee
Re: Wide Band Gap and Harsh Environment Semiconductor RD&D Capability Proposal
Date: Monday, April 20, 2015

Dear IGEM Committee,

This letter is in support of Dr. Eric Burgett's proposal entitled Wide Band Gap and Harsh Environment Semiconductor RD&D Capability. This proposal has the support of the university and is a one component of the strategic mission of the RISE Complex here at Idaho State University. The proposal builds on a significant infrastructure built at the RISE Complex by Dr. Burgett and his research team.

By siting this work at the RISE Complex, Dr. Burgett can continue to educate the best students for jobs, which will transition directly into the workplace, and with this grant, have that workplace be centered here in Pocatello.

The two industry collaborators have committed significant up-front support for this project, both in terms of financial and resource/personnel commitments, and have begun negotiations with the University for licensing and commercialization rights with the proposed technology. We wish to keep that work here in Idaho, which is aligned with IGEMS's mission. This grant would further that educational and commercialization goal.

Sincerely,

Cornelis J. Van der Schyf
Vice President for Research

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NuMat
MATERIAL INSPIRATION

20 April 2015

Harry Joseph Nause Jr.
President, NuMat, Inc.
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Dr. Cornelis Van der Schyf
Vice-President for Research and Economic Development
Idaho State University
921 S. 8th Ave., Stop 8130
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Sir,

NuMat Inc. (NuMat) is a small R&D and technology commercialization business with big dreams. We have recently reorganized and restructured our personnel and business plans and believe that partnering with Idaho State University is the path by which we will most rapidly realize our goals.

Recently, we entered discussions with Idaho State University (ISU) to develop a Technology Development and Licensing Agreement (TDLA) that would provide NuMat Inc. (NuMat) with access to cutting edge technologies being developed by Dr. Burgett and to the RISE Complex in support of ISU research and education goals. The goals of Dr. Burgett meld well with NuMat's business goals of bringing game changing technology to market. Our hope is to mutually benefit from the continued development and deployment of advanced technologies and we see Dr. Burgett's technology as well as him and his trained staff as a strategic advantage. We see this partnership as an important one in the development of our business and important to the growth and success of ISU and its researchers.

We are aware of the Idaho Global Entrepreneurial Mission (IGEM) and its mandate to spur innovation and economic development in Idaho. As such, NuMat would like to partner with ISU on Dr. Burgett's IGEM proposal to procure key research and fabrication equipment that would improve research capabilities at ISU. Dr. Burgett's equipment is at capacity, and this increase in capability and quantity will improve business opportunities for NuMat, provide expanded research capabilities and opportunities for ISU, and result in economic development for southeastern Idaho.

Using the equipment procured with this IGEM grant, we propose to work with ISU to engage in research, development, and commercialization activities of wide band gap and harsh environment crystals and semiconductors in a variety of materials; beginning with zinc oxide. This activity would be in addition to the research topics we have already proposed in our draft TDLA.

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Specifically, we propose to work with ISU to develop research and fabrication capabilities at RISE that will allow NuMat to improve some of its proprietary technologies working in concert with those components of intellectual property developed by Dr. Burgett and use them to produce and sell vastly improved specialized crystal materials and substrates suitable for industrial and research purposes. We would also conduct R&D on applications of these materials leading to the creation of valuable new intellectual property that would be used by NuMat to expand sales as well as create licensing and royalty opportunities.

The investment by the State of Idaho and intellectual property developed by Dr. Burgett would provide NuMat with access to an initial fabrication capability that should lead to a competitive advantage based on the larger size of the fabricated crystals than is currently available commercially. This advantage will allow NuMat to quickly generate revenues that we would use to fund research at RISE as well as hiring new employees and making expansions to fabrication capability. By housing NuMat initially at the RISE Complex, NuMat would maintain a significant and growing presence in the state for the foreseeable future.

Our analysis shows that sales of zinc oxide crystals on sapphire substrates alone could generate over $2.5 million in net revenues within the first year. Addition of a second product line based on bulk crystals of zinc oxide could boost this figure to over $10 million in the first year. These net revenue estimates account for NuMat funding all relevant patent costs, paying ISU a royalty on all licensed intellectual property, providing a licensing fee to ISU for all jointly developed intellectual property, and funding sponsored research and development at the RISE Complex. In terms of employment in Idaho, NuMat proposes to hire at least one crystal growth engineer soon after an IGEM award is granted and, depending on sales growth, a second and subsequent hires would occur within the first year, all who would work at the RISE Complex.

NuMat looks forward to working together to submit an IGEM proposal and using this to expand our collaborations for our mutual benefit and the benefit of southeastern Idaho.

Sincerely Yours,

Harry Joseph Nause, Jr.
President, NuMat Inc.

EJ Proprietary Properties

Jeff Shorty
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Dr. Cornelis Van der Schyf
Vice-President for Research and Economic Development
Idaho State University
921 S. 8th Ave., Stop 8130
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Dear Dr. Van der Schyf,
EJPP is a small high tech R&D Company based around the commercialization of harsh environment semiconductor materials. We are developing the market nitche as a semiconductor growth and fabrication company. We are currently negotiating the IP and commercialization rights to the harsh environment semiconductor technology, which has been developed by Dr. Burgett. The proposed effort of Dr. Burgett and the IGEM program meld well with our intended business goals.

We continue to focus on the commercialization of the harsh environment semiconductor materials for the energy sector. The enhanced throughput and capabilities proposed by Dr. Burgett will play a significant role in the demonstration of this new technology. Having access to the intellectual property and students of Dr. Burgett and the RISE Complex as well as this added capability will foster the growth of our company. We see this partnership as an important one in the development of our business and important to the growth and success of ISU and its researchers.

Dr. Burgett made our company aware of the Idaho Global Entrepreneurial Mission (IGEM) and its mandate to spur innovation and economic development in Idaho. We have been working collaboratively on his extreme and harsh environment semiconductor technology for over a year now. By increasing the capabilities at RISE, this added capacity and capability will improve commercialization opportunities for EJPP as well as enhance the existing R&D DOD portfolio of the RISE Complex allowing us to enter into broader commercial scale R&D proposals with our DOD clients. These grants along with our commercialization efforts will result in economic development in the Pocatello and southeastern Idaho regions.

The investment by the State of Idaho and intellectual property developed by Dr. Burgett would provide EJPP the starting point to commercialize and establish a strategic market advantage based on the novel

nature of the growth equipment and IP developed by Dr. Burgett. These advances make his harsh environment semiconductors game changers in the electronics and power sectors. These advantages will position EJPP and the supporting consortium in a position to bring this technology to the marketplace rapidly. By working jointly at the RISE Complex with Dr. Burgett, this will establish EJPP as an Idaho company and grow it's presence here in Idaho. We realize the added value this proposal brings to SE Idaho and strongly endorse it to move forward.

EJPP has provided an initial licensing and commercialization agreement to Idaho State University. As part of this agreement and this grant, we are offering a percentage of revenue as well as a royalty payment of in excess of $125,000 dollars per year for 5 years to ISU to support this grant and the commercial development of this technology based on the outcome of current negotiations with ISU. EJPP also envisions hiring several new employees and housing them at the RISE Complex to support the increased R&D effort this project aims to complete. We will provide employees to the cohort Dr. Burgett will be training to effectively create a unified skilled workforce to transition into commercial production here locally in Idaho.

EJPP looks forward to working together to submit an IGEM proposal and using this to expand our collaborations for our mutual benefit and the benefit of southeastern Idaho.

Sincerely Yours,

Jeff Short
President, EJ Proprietary Properties

Appendix D

Economic Development

Economic multipliers vary by geographic region. *From the book The New Geography of Jobs – May 22, 2012 by Enrico Moretti:*

With only a fraction of the jobs, the innovation sector generates a disproportionate number of additional local jobs and therefore profoundly shapes the local economy. A healthy traded sector benefits the local economy directly, as it generates well-paid jobs, and indirectly as it creates additional jobs in the non-traded sector. What is truly remarkable is that this indirect effect to the local economy is much larger than the direct effect. My research, based on an analysis of 11 million American workers in 320 metropolitan areas, shows that for ***each new high-tech job in a metropolitan area, five additional local jobs are created outside of high tech in the long run***.

[And] it gets even more interesting. These five jobs benefit a diverse set of workers. Two of the jobs created by the multiplier effect are professional jobs — doctors and lawyers —while the other three benefit workers in nonprofessional occupations — waiters and store clerks. Take Apple, for example. It employs 12,000 workers in Cupertino. Through the multiplier effect, however, the company generates more than 60,000 additional service jobs in the entire metropolitan area, of which 36,000 are unskilled and 24,000 are skilled. Incredibly, this means that the main effect of Apple on the region's employment is on jobs outside of high tech.

Appendix E

References Sited

[1] www.compoundsemiconductor.net/article/90685-zno-technology-could-revolutionise-leds-and-uv-lasers.html , article dated 25 Apr 2013

[2] http://www.zinc.org/info/ultraviolet_lasers_and_leds_made_from_zinc_oxide_are_on_their_way

[3] http://ntechresearch.com/articles/trends-in-materials-for-radiation-detection#sthash.DNjXZZ8h.dpuf

[4] http://www.cnet.com/news/life-after-silicon-how-the-chip-industry-will-find-a-new-future/