COVER SHEET FOR GRANT PROPOSALS

State Board of Education

SBOE PROPOSAL NUMBER: (to be assigned by SBOE)	AMOUNT REQUESTED: **$1,200,200**

TITLE OF PROPOSED PROJECT: *Enhancing Capabilities in Nanotechnology and Microfabrication at Boise State*

SPECIFIC PROJECT FOCUS: Boise State University seeks to upgrade the materials characterization and microelectronic processing capability of the Idaho Microfabrication Laboratory (IML), supporting technology development and economic growth in the State of Idaho. The primary objectives of this project are to:

a. Augment existing capabilities of the IML and Nanotechnology Research Corridor at Boise State.
b. Expand expertise in emerging research areas of flexible/printed electronics, thin-film and 2D materials, and neuromorphic computing.
c. Forge stronger industrial partnerships and collaboration and deliver more direct access to the advanced facilities and research at Boise State.
d. Provide additional opportunities for both industrial and academic education and training in nanotechnology and microelectronics.

Advanced processing techniques are critical to the successful development and manufacturing of new materials and electronic devices. This project upgrades the infrastructure and improves capabilities in the Idaho Microfabrication Laboratory such that it can continue to support research throughout Idaho as well as catalyze product development and manufacturing in the State.

PROJECT START DATE: 07/01/2015	PROJECT END DATE: 06/30/2018
NAME OF INSTITUTION: Boise State University	DEPARTMENT: Office of Sponsored Programs
ADDRESS: 1910 University Drive, Boise, Idaho 83725-1135	
E-MAIL ADDRESS: osp@boisestate.edu	PHONE NUMBER: 208-426-4420

	NAME:	TITLE:	SIGNATURE:
PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR	Kurtis Cantley, Ph.D.	Assistant Professor	Kurtis B Cantley
CO-PRINCIPAL INVESTIGATOR	Amy Moll, Ph.D.	Dean, Professor	A Moll

NAME OF PARTNERING COMPANY:	COMPANY REPRESENTATIVE NAME:

Karen Henry, Executive Director, Office of Sponsored Programs SIGNATURE:

Authorized Organizational Representative		Karen Henry 4/28/15

SUMMARY PROPOSAL BUDGET

Name of Institution: Boise State University
Name of Project Director: Kurtis Cantley

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

Name/ Title	Salary/Rate of Pay	Fringe	3 year total rounded Dollar Amount Requested
Technical Support Engineer (to be hired, years 1-3)	$65,000 year 1	$76,345	$277,300
Graduate Student (to be hired, years 2-3)	$26,000 year 2	$3,640	$55,600

% OF TOTAL BUDGET: 27.7% SUBTOTAL: $332,900

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

Item/Description	Dollar Amount Requested
Leatherwood Plastics RCS Acid Wetbench, year 1	$85,400
Leatherwood Plastics Solvent Process Bench with Ultrasonics, year 1	$104,000
Hidden Analytic SIM 7-2 3000 Mass Sec Ion Mill End Point Detector, year 2	$85,100
Fuji Dimatix DMP-2831 Materials Printer, year 3	$55,000
CDA Dryer, year 1	$6,000
DektakXT Profilometer, year 3	$72,300
Samco RIE-1C, year 3	$60,200
Equipment installations (estimate 10% capital expenditure)	$46,800
SUBTOTAL:	$514,800

G. TRAVEL:

Dates of Travel (from/to)	No. of Persons	Total Days	Transportation	Lodging	Per Diem	Dollar Amount Requested
					SUBTOTAL:	$0.00

H. Participant Support Costs:

	Dollar Amount Requested
1. Stipends	
4. Other	
SUBTOTAL:	$0.00

I. Other Direct Costs:	Dollar Amount Requested
1. Materials and Supplies $15,000 per year for three years	$45,000
2. Publication Costs/Page Charges	$0.00
3. Consultant Services (Include Travel Expenses) Service Contracts=$20k y1, $35k y2 , and $50k y3	$105,000
4. Computer Services	$0.00
5. Subcontracts	$0.00
6. Other (specify nature & breakdown if over $1000) Faculty Start-up = $100,000; Electrical Power Upgrade=$25,000; Chilled water upgrade=$30,000; Vacuum System Replacement (pump and plumbing)=$24,900; Student Fees=$22,600	$202,500
SUBTOTAL:	$352,500

J. Total Costs: (Add subtotals, sections A through I)	**TOTAL:**	$1,200,200
K. Amount Requested:	**TOTAL:**	**$1,200,200**

Project Director's Signature: Kristin O Carthy   Date: 4/23/2015

INSTITUTIONAL AND OTHER SECTOR SUPPORT (add additional pages as necessary)	
A. INSTITUTIONAL / OTHER SECTOR DOLLARS	
Source / Description	Amount
B. FACULTY / STAFF POSITIONS	
Description	
C. CAPITAL EQUIPMENT	
Description	
D. FACILITIES & INSTRUMENTATION (Description)	

Enhancing Capabilities in Nanotechnology and Microfabrication at Boise State

1) ***Name of Idaho Institution:*** Boise State University

2) ***Name of Principal Investigator:*** Kurtis D. Cantley, Assistant Professor, ECE

   Co-Principal Investigator: Amy Moll, Dean, College of Engineering

3) ***Project Objectives:***

a. Augment existing capabilities of the Idaho Microfabrication Laboratory (IML) and Nanotechnology Research Corridor at Boise State.

b. Expand expertise in the emerging research areas of flexible/printed electronics, thin-film and 2D materials, and neuromorphic computing.

c. Forge stronger industrial partnerships and collaboration and deliver more direct access to the advanced facilities and research at Boise State.

d. Provide additional opportunities for both industrial and academic education and training in nanotechnology and microelectronics.

   Amount Requested: $1,200,200

4) ***Resource Commitment:*** The economy of the Treasure Valley area is heavily driven by the microelectronics industry. With significant support from several local companies, Boise State has developed academic programs and prioritized research investments that provide the greatest benefit to the region. Doctoral programs in Electrical & Computer Engineering and Materials Science & Engineering were created in the past ten years with a primary emphasis on providing educational and research opportunities for graduate and undergraduate students, faculty, and external partners in the microelectronics industry.

Further evidence of this commitment came in 2009 when the College of Engineering completed work on a new cluster of laboratory space labeled the Nanotechnology Corridor. Necessitated by the increasing demand for research on electronic materials and devices, this cluster is comprised of nine labs. It is anchored by the Idaho Microfabrication Laboratory (IML), which consists of a 900 ft^2 class 1000 cleanroom, a 1500 ft^2 process lab, a 700 ft^2 microscopy lab, and a 900 ft^2 metrology lab. The IML was originally created in 1998 and is dedicated to the research and advancement of materials and processes used in microelectronic device fabrication.

More specifically, the IML is equipped to perform deposition, etching, micro- and nano-scale patterning, and characterization of different types of materials. The initial investment by Boise State was approximately $1.0M. Subsequent upgrades totaling over $863,000 have expanded the capability and capacity of the IML. The College of Engineering also provides funding for one full-time staff member to manage the facility and oversee student employees. Additional staff members provide research support for the IML on a part-time basis. Boise State has consistently supported the operations of the IML and other nanotechnology processing capabilities. However, the equipment and infrastructure have not kept pace with advances in the field.

5) Specific Project Plan: Manufacturing of advanced microelectronic devices is a significant driver of Idaho's economy. Economic growth in this industry is enabled by innovative research and development using advanced processing techniques to create new materials, structures, and devices. These new products have broad impacts in industries as diverse as agriculture, medicine, transportation, and energy. This project upgrades the infrastructure and improves capabilities in the IML such that it can continue to support research throughout Idaho as well as catalyze product development, commercialization, and advanced manufacturing in the state.

The IML supports the activities of a wide variety of researchers on campus investigating technologies ranging from new chalcogenide materials for memory devices to the use of DNA as a nanotechnology scaffold for photonic devices. Large and small companies have used the IML to explore and develop new processes. Micron Technology did exploratory work on electron-beam lithography to further reduce the size of memory devices. QTI investigated a new way to deposit metal contacts on their industry leading thermistors. In Appendix C, a representative group of local companies have provided letters of support for this investment in the IML and indicate their intent to partner with Boise State on this project.

By enhancing the capabilities of the IML and nanotechnology fabrication at Boise State, we can serve Idaho by educating the current and future workforce, offering programs that will support local companies, and conducting leading edge research that attracts external funding. To accomplish these goals, this project has four main strategies which are outlined below.

Strategy 1: Infrastructure improvements and additional support staff to increase operational efficiency and capability of the Nanotechnology Corridor and IML.

Facility Upgrades: i) Electrical power: Electrical service in the IML has been fully allocated to existing equipment. Installing an additional 200 amps will allow for expansion and installation of new equipment. *ii)* Chilled water: The capacity of the current chilled water system is not adequate to meet current needs. The installation of control components is required to operate the two exiting water chillers in parallel. *iii)* Vacuum system: The current vacuum system is inadequate due to an undersized pump and leaky lines. The main vacuum pump will be replaced and the vacuum lines will be rerouted throughout the facility.

Equipment: i) Wet bench for acid processing: The current wet bench is 15 years old and requires replacement due to reliability and safety concerns. A replacement system will incorporate improved process controls, environmental monitors, and integrated waste treatment capabilities. *ii)* Wet bench for solvent processing: The current wet bench combines both acid and solvent processing capability. While this may occasionally occur in industrial settings, it is far less desirable in a research/teaching lab for safety reasons. A replacement wet bench will provide stand-alone solvent processing and waste disposal separate from the acid processing system. *iii)* Stylus profiler: Purchase of a stylus profilometer will allow measurement of patterned surface features in the micron range. *iv)* Materials inkjet printer: Similar to other inkjet technology, a materials inkjet printer allows precise placement of small volumes of fluid over a large substrate and enables rapid prototyping of microelectronic systems. *v)* Mass-spectrometer end point detector for the ion mill: The ion mill uses argon plasma to etch nanoscale features in materials. The purchase of an endpoint detector for the ion mill will automatically halt the etch process when a specified measurement condition is met, providing more precise control of the process. *vi)* Reactive ion etch (RIE) tool: With the ability to generate oxygen and fluorine-based plasmas, the RIE is a versatile tool used in many important fabrication process steps. *vii)* Service contracts: Maintenance on the current tools in the IML and the proposed new tools is critical to maximize their usable lifetime. The processes that are carried out in the IML require multiple, sequential steps. If a required tool is not available, the process must stop and wait for repairs, and potentially restart from the beginning, which severely affects research productivity.

Technical Support: The IML is currently managed by one full-time staff engineer/director and temporary, part-time student help. In addition to the daily operational duties of scheduling work, training students, ordering supplies, and managing finances, the IML director is also responsible for process development, equipment troubleshooting and repairs, and managing new equipment installations and equipment overhauls. As mentioned above, equipment downtime can have detrimental impact on productivity. This proposal requests the addition of a temporary, full-time engineer to aid in IML operations including maintenance and troubleshooting.

Strategy 2: Expand expertise in three specific research areas by providing funds for new equipment and start-up for one new faculty member and graduate students.

At Boise State, we have developed expertise in three particular emerging research areas, which we will enhance with this proposal.

Flexible/Printed Electronics: Printed and flexible electronics can provide relatively low-performance components and devices at a very low cost. Such technologies will drive demand for disposable or short lifetime devices that can be integrated into items such as clothing or placed directly on the skin (wearable electronics). The most adaptable of the various technologies used for printing electronic inks is inkjet printing. Inkjet printers provide the highest level of control and precision for deposition of functional ink solutions in low-volume manufacturing operations.

Thin-film and 2D Materials: As the inherent limitations of silicon as a material for semiconductors are approached, research efforts are now focused on the development of alternate processing methods, new materials, and devices that operate in fundamentally different ways. Two-dimensional (2D) materials have emerged as one of the most promising new developments in electronic materials. 2D materials are sheets of material a single atom or molecule thick that exhibit novel mechanical, thermal, electrical, and magnetic properties. Researchers are investigating methods to exploit the unique properties of these materials in applications including photovoltaics, batteries, and semiconductor devices. The expanded capabilities of the IML are critical for this research.

Neuromorphic Computing: Neuromorphic computing utilizes electronic devices and circuits that emulate the neurons and synapses found in the brain and nervous system. Constructing biomimetic artificial neural networks can be accomplished with a new class of devices called memristors. These devices have resistance which is related to the current that has previously flowed through the device, i.e. the present state (resistance) of the memristor is based upon its "memory" of past current flow, and not upon the instantaneous current. In this way, memristors are like synapses, which modify the strengths of neuronal connections based on past activity. Our ability to process sensory inputs, learn, and remember are inherent from the synapses, and memristors open the possibility to create solid state devices capable of cognitive functions. Boise State research teams have already provided breakthrough research for the commercialization of functional memristor devices based upon ion-conducting chalcogenide materials.

Additional Faculty: While there are multiple users of the listed facilities in the College, this proposal requests start-up funding for an additional faculty member and two years graduate student support. This new faculty member would be expected to have expertise in at least one of the emphasis research areas and to pursue external funding for his/her research.

Strategy 3: Increase industrial partnerships and research collaborations with Boise State by providing more direct access to the capabilities of the IML.

Industrial partnerships are critical to the long term success of the proposed project and sustainability of the IML. This project provides a means to strengthen our relationship with Idaho companies by providing expanded materials processing and characterization capabilities and access to research at Boise State. Our ultimate goal is to move discoveries from R&D to manufacturing and commercialization. The Idaho companies who are partnering with Boise State on this proposal are interested in a wide variety of capabilities. These companies vary from small, locally owned start-ups to multi-national institutions like Micron Technology. Each company has different needs and interests. By expanding our capabilities we can offer additional services to the smaller companies and allow them to explore new processes and partner with us on future research. These opportunities will lead to new products developed and manufactured in Idaho. Another avenue for partnership is senior design projects or multi-year student projects. By enhancing our processing capabilities, we offer new ways to expand our partnerships.

The first step in this direction will be the creation of an Industrial Advisory Board (IAB). The primary role of this group will be to provide guidance as it relates to operation and maintenance of the IML. In addition, diversity of backgrounds and focus on marketing the facility will expand visibility of the IML and help foster research collaboration.

Strategy 4: Create additional education and training opportunities in the areas of nanotechnology and microelectronics for industrial partners and students.

Academic Education: The College of Engineering already offers several courses at the undergraduate and graduate level which utilize the IML or other facilities in the Nanotechnology Corridor. Expanded capabilities in the IML will enhance these courses which are typically taken by engineering students majoring in ECE or MSE. These courses are also of interest to working process and manufacturing engineers at local companies.

Industrial Training: In this project, a workshop or short course would be created to offer training to users outside Boise State on a periodic basis. Although several small companies currently utilize the IML at some level, increased exposure of their employees to the facility not only increases their likelihood of future use, but can provide those employees with new ideas and knowledge. At larger companies, giving process technicians the opportunity for more hands-on exposure would also help develop fundamental understanding of various fabrication processes.

In addition, we will develop a short course or workshop for the employee in these industries who does not have a technical background but is in a position where developing a basic understanding of the processes and fabrication technology would support their overall work. These employees may work in finance or marketing or HR for companies for one of our partners. All new training opportunities would be developed with input from our IAB

6) *Potential Economic Impact:*

Training and Education: As outlined in strategy 4, training students in semiconductor processing technology has always been a primary mission of the IML. The IML will continue to equip graduating engineers with the skills necessary to competently contribute as a new hire in industry. Corporate training programs will also be provided as described in Strategy 3. The impact of training and the creation of a trained workforce to support the high tech industry is a critical factor impacting the growth of the fabrication industry in Idaho. As an example, a recent search of open positions at Micron Technology (April 22, 2015; jobs.micron.com/go/jobs-in-the-United-States/389159) resulted in 151 current openings. All of these positions are located at the Boise, Idaho facility and have the word “Engineer” in the job title. A broader search shows an additional 108 openings at the Micron, Boise facility, most of which require a technical understanding of the processes and products produced by Micron.

External Funding: With increased capability of the IML, both from new equipment installations and additional technical support, we anticipate success in obtaining increased grant funding requiring use of the IML facilities. We also expect increased use by local companies.

IP Generation: A longer term goal will be the creation of intellectual property (IP) from activities enabled by the IML. IP generation may occur either from faculty managed projects or by private users of the IML and would generally consist of patents or patent applications.

Economic Development: We expect the new capabilities requested in this proposal to benefit our current and future partner companies in a variety of ways. Primarily, it will allow these companies to perform research and development activities for which they are not equipped because doing so would be too costly. Going further, we would then offer the potential to expand their business by improving the performance or increasing yields of existing products in addition to developing completely new products. The R&D capabilities offered by the IML would thus enable companies not only to increase current market share, but to potentially enter completely new markets. In larger companies, it is often not advantageous to run advanced equipment for any purpose aside from actual manufacturing, whereas the IML provides a secondary space.

7) Criteria for Measuring Success:

Project Deliverables: As outlined in section 5, the goals of this project are very diverse. However, the main deliverables and their timelines for completion are: *i)* Equipment installations: The costs and infrastructure requirements for the advanced equipment requested in this proposal varies widely, as will the timelines for installation. A general goal will be to acquire new equipment within 1-3 months after the beginning of the fiscal year in which it is budgeted and have it commissioned in an additional 3-6 months (total time frame of 4-9 months). *ii)* Technical support position: This position will be filled with a qualified candidate within the first four months of the project. *iii)* Establishing the IAB: The initial membership selection will occur in the first quarter of the project, with meetings held quarterly thereafter. *iv)* New faculty: Hiring of the new faculty member will take place at the beginning of the second year of the project.

Economic Impact Metrics: The potential economic impacts of this project outlined in section 6 will be measured as follows: *i)* Training students: The number of student credit hours and actual total hours of training provided each academic year. *ii)* External funding awards: This metric will assess the number of submitted proposals using the IML, total dollar amount requested and percentage allocated to IML, and the number of grants awarded. *iii)* IP generation: This will be measured by the total number of patent applications and scholarly articles and presentations facilitated by the IML. *iv)* Use of Boise State microfabrication and nanotechnology capabilities by our partners.

8) Budget and 9) Budget Justification: The total budget request is $1,200,200. Of this amount, $332,900 is allocated to salary and benefits of the support engineer (3 years) and graduate student funding (2 years). $514,800 is allocated capital equipment purchases, $100,000 for faculty start-up, and the remaining $252,500 is allocated to infrastructure upgrades, service contracts, student fees, and other expenses. These amounts are justified based on the tools costs for the desired capability enhancement, as well as competitive salary and start-up packages. Please note that the capital purchases are based upon procurement estimates for new equipment. The project team will however, make every effort to obtain reliable and capable equipment on the used equipment market at reduced cost, and will then request reallocation of unused funds.

10) Institutional Commitment: Boise State currently supports the IML by paying the director, providing administrative support, providing safety support and covering the costs of repairs to equipment. The operating supplies for the lab are covered with user fees. Boise State is committed to the success of this laboratory and providing access to a wide variety of users. We will strengthen the management structure of the laboratory by creating an advisory board and appointing leadership of a faculty oversight committee. We will continue to expand the user base and apply for external funding to consistently upgrade the capabilities of the IML.

11) Additional Institutional and Other Sector Support: We are striving to offer capabilities and programs that are of interest to our industrial partners through this project. We have not asked for a specific dollar amount of support rather we are working to ensure that our partners have access to the processes and the educational opportunities that are of interest to them. The training component of this project will also be covered by tuition or a fee (for workshops). The following partners have provided support letters (see Appendix C): *i)* Micron; *ii)* QTI; *iii)* ASI; *iv)* PakSense; *v)* BIT; *vi)* PKG; *vii)* Western Electronics; *viii)* NxEdge; *vix)* MicroSil.

Appendix A: Facilities and Equipment

General Laboratory Facilities

The combined facilities available within the college and university supporting microelectronics fabrication and nanotechnology consist of molecular beam epitaxy growth labs, device characterization labs, a photonics lab, two labs dedicated to scanning probe microscopy, nano/microfabrication facilities, materials characterization facilities, and general lab space. In addition, the college has a fully-staffed machine shop, electronics shop, and shared-use facilities at Boise State University and Center for Advanced Energy Studies. Details of the equipment available are provided below.

Idaho Microfabrication Laboratory (IML)

The Idaho Microfabrication Laboratory is located in the Engineering Building in the south part of the building on the first floor. The IML consists of a small gowning room, a 900 ft^2 Class 1000 cleanroom, a 1500 ft^2 process lab, a 700 ft^2 microscopy lab and a 900 ft^2 metrology lab. The IML is equipped to fabricate microstructures using photolithography methods along with deposition and etching processes. The IML is equipped with basic facilities which service all of the equipment located in the four IML spaces. A process cooling water loop provides system cooling during equipment operation as well as standby cooling needs. Clean dry air (CDA) is provided to service equipment requiring air for pneumatics. DI water is available for wafer processing. A house vacuum system is also available for low vacuum needs and compressed gas is provided by either point-of-use locations or via the IML gas room, housing most of the process gas cylinders. Pumped exhaust and fume hood ventilation are taken care of by a dedicated exhaust system incorporating a 5000 cfm explosion proof exhaust fan and PVC coated exhaust ducting for corrosive gas process applications. Located in the IML gas room is a hazardous gas cabinet which houses the silane gas cylinder used by a PECVD tool. Specific capabilities and tools are listed below:

- Photolithography
    - Contact Aligner – Quintel Q-4000
    - Proximity/Contact Mask Alignment System – QAI 5000
    - Spin Coater – Headway Research – PWM 32-PS-R 790
- Dry Etching
    - DRIE Etcher – Oxford Instruments – Plasmalab 100
    - Branson Asher – Dionex 3000
    - Ion Beam Milling Machine – Veeco 100
- Physical Vapor Deposition (PVD)
    - Magnetron Sputter Tool – Sputter Sciences – CrC150
    - Magnetron Sputter Tool – AJA International – Orion 5
    - Thermal Evaporator – CHA 600
- Thermal Processing
    - Oxidation and Diffusion Furnaces – Minibrute 80
    - Rapid Thermal Profiler – Modular Process Technology Corp. – RTP600S
- Wet Processing
    - Chemical Wet Processing Station – SCP Global
    - Spin Rinse Dryer – Semitool – ST460
- Electronic Processing
    - Wafer Dicing/Scribing – ADT – ADT982-6
    - Wire Bond – WestBond – Model 7476

  - Wire Bond – K&S Wedge Bonding – Model 4526
- Characterization
  - Ellipsometer – Gaertner Scientific – L115C8
  - Nanospec – Nanometrics – 212
  - Optical Surface Profiler – WYKO – NT1100
  - Four Point Probe – Superior Electronics – AFPP500
- Scanning Electron Microscopes (SEM)
  - Leo 30 keV Scanning Electron Microscope - Model 1430 Variable Pressure
    - Electron beam lithography - Nanometer Pattern Generation System from JC Nabity Lithography Systems
    - Energy dispersive spectroscopy – Oxford
    - Electron Backscatter Diffraction system
  - Hitachi S-4500 FE SEM

Surface Science Laboratory

The Surface Science Laboratory (SSL) is a shared-use facility located in a 450 sq. ft. state-of-the-art room designed for scanning probe microscopy. This facility is managed by Dr. Paul Davis whose expertise in scanning probe microscopy and Raman Spectroscopy can be leveraged in characterizing materials. To ensure a low noise environment, isolated concrete slabs are utilized for each of the following instruments housed within the SSL:

- Bruker Dimension Icon atomic force microscope (AFM) with Nanoscope V controller and additional FastScan head, X-Y-Z closed loop scanner, 8 simultaneous real-time data capture channels, high resolution 5k x 5k imaging, high speed scanning, PeakForce

QNM, PeakForce TUNA, Conductive AFM, Capacitance AFM, MFM, nanolithography & nanomanipulation, thermal stage (-35 °C to 250 °C), and fluid cell

- Bruker Picoforce Multimode 8 AFM with Nanoscope V controller, TS-140 Herzan active vibration isolation table, custom acoustic enclosure, 8 simultaneous real-time data capture channels, ScanAsyst and ScanAsyst-HR, PeakForce QNM, PeakForce TUNA, Conductive AFM, thermal stage (room temperature to 50 °C), and fluid cell
- Bruker Dimension 3100 AFM with Nanoscope IV controller, X-Y closed loop scanner, Hysitron TS 75 Triboscope Nanoindentation System, torsional harmonic imaging, Conductive AFM, Tunneling AFM, Capacitance AFM, MFM, nanolithography & nanomanipulation, 3 simultaneous real-time data capture channels, 1k x 1k resolution, thermal stage (range: -35 °C to 250 °C), and fluid cell
- FEI Phenom tabletop scanning electron microscope (SEM) with 5 keV source, 24x fixed optical and 525-240,000x variable electron magnification
- Herzan 3-axis vibration accelerometer system
- Novascan PSD-UVT ultraviolet/ozone system

MULTI-PROBE MICROSCOPY LABORATORY

The Multi-probe Microscopy Laboratory (MML) is a located in a 530 sq. ft. state-of-the-art room designed for scanning probe microscopy with acoustically isolated floor, walls, and ceiling. Facilities include:

- Nanonics Hydra/MV4000 Multi-probe BioAFM/SPM with liquid cell, dual probes. Capable of AFM, conductive AFM, thermal conductance microscopy, imaging in fluid, magnetic force microscopy, electrophoretic deposition, conventional NSOM, near-field and far-field fluorescence, Si APD detector, Photomultiplier tube

- Coherent Chameleon 100 fs 4 W Ti:Sapphire mode-lock laser (80 MHz repetition rate)
- Coherent Mira OPO
- Nikon Ti-U TIRF-Epi Microscope with custom laser port and Princeton Instruments ProEM 512 CCD cameras for imaging and spectroscopy with a Princeton Instruments 500 mm spectrometer.
- Thorlabs, NanoMax 5-axis fiber alignment stage
- Multiple solid-state lasers (405 nm, 450 nm, 532 nm, 675 nm)
- Several single frequency continuous wave (CW) diode lasers are available at wavelengths of 630, 730, 850, 980, 1310, and 1550 nm.
- Ando Optical spectrum analyzer: It covers from 350 nm to 1750 nm with a noise level of -90 dBm. The equipment is capable of ±0.05 nm wavelength resolution and ±0.02 nm wavelength linearity.
- Stanford Research Picosecond Delay Generator
- Newport power meter with optical detectors and energy detectors
- Newport Dual Source Xe, W light source
- Newport Cornerstone 260 1/4m Monochromator
- Free space and fiber based Polarimeter: automated system for polarization measurement from 400 nm to 1700 nm
- 1.3 GHz Network analyzer, 2 GHz RF signal generator, 1.3 GHz spectrum analyzer
- 2 Coherent energy detectors

Transport Characterization Laboratory

The Transport Characterization Laboratory includes three advanced electrical characterization systems and 5 probe stations. One of the probe stations is a custom design closed cycle cryogenic system.

- Horiba LabRamHR Evolution Confocal Raman Microscope X-Y-Z mapping with 633nm, 532nm, 473nm, and 442nm excitation wavelengths.
- 3 Advanced DC & sub-RF Electrical Characterization Systems (Computer Controlled)
- 2 Keithley 4200, 100 aA resolution, dual-channel pulse generator pulse I-V (100 ns rise/fall time and 40-150 ns pulse width, duty cycle: 0.01 to 99% 0-5V, quiescent point pulsing), switch matrix, 20Hz-1MHz C-V, built-in 2-channel 750MHz digital o-scope, Quasi-static CV
- Agilent 4156C semiconductor characterization system with switch matrix
- 3 HP 4284A LCR meters (20Hz to 1MHz)
- Probe Stations: 1 closed-cycle cryogenic with actively cooled probes (5.5 to 450 K), 1 high temperature (673K), 2 room temperature
- Low Noise Spectroscopy System
- Agilent 4294A precision impedance analyzer
- 2 SRS SR830 dual phase and SRS SR810 single phase lock-in amplifiers
- 1GHz 4 channel 4GSamples/s Mixed Signal oscilloscope
- ~25 Cascade micromanipulator probes (4 high temperature)
- Janis CCS-400H/204N high temperature, optical cryostat system with sample in vacuum (10 K to 800 K), 19 pin electrical feed-through, LakeShore Model 335 temperature controller, and Model TS-75-D turbo-pumping station

Integrated Nanomaterials Laboratory – Boise State University

The Integrated Nanomaterials Laboratory is housed within Boise State University's Environmental Research Laboratory and is equipped with a fume hood suitable for a variety of wet chemistry experiments including nanomaterials synthesis. The following key pieces of equipment are available in this laboratory:

- Axon MultiClamp 700B patch clamp amplifier on a vibration isolation table
- Axon Digidata 1550 low-noise data acquisition system
- pClamp 10 electrophyisology data acquisition and analysis software
- Custom built quartz tube variable pressure chemical vapor deposition system with 4 inlet gases and up to two solid-source precursors.
- QSonica Q125 probe-tip ultra-sonicator
- Branson 2800 variable temperature ultra-sonicator
- 6 Eppendorf adjustable volume pipettes
- 6 Fisherbrand mini-centrifuges
- Mettler Toledo Analytical Balance
- Thermo Scientific Legend Micro 21 Microcentrifuge
- Think Planetary Centrifuge
- Thermo Scientific Heratherm Programmable Gravity Convection Oven
- Heraeus Megafuge 8 with TX-150 Cell Cult Pkg (8 x 50 ml)
- MTI 2" Quartz Tube furnace with inert gas inlet and vacuum compatible

- Janis CCS-400H/204N high temperature, optical cryostat system with sample in vacuum (10 K to 800 K), 19 pin electrical feed-through, LakeShore Model 335 temperature controller, and Model TS-75-D Turbopumping station
- Agilent and Varian Eclipse Fluorescence Spectrophotometers
- Agilent Cary 5000 uv-vis-nir spectrophotometer

Shared-Use Facilities

Center for Advanced Energy Studies

The Center for Advanced Energy Studies is a research and education partnership between Boise State University, Idaho National Laboratory, Idaho State University, and the University of Idaho.

- FEI Tecnai TR30FEG STwin Scanning Transmission Electron Microscope
- JEOL JSM-6610LV Scanning Electron Microscope with EDS/EBSD/CL
- TI-950 TriboIndenter Nanoindenter and Atomic Force Microscope
- LEAP 4000X HR Local Electrode Atom Probe
- Quanta 3D FEG Focused Ion Beam with EDS/EBSD/Omniprobe
- Spark Plasma Sintering System
- Molten Salt Glove Box

Center for Materials Characterization (Dept. of Materials Science and Engineering)

JEOL JEM-2100 HR Analytical TEM

- Bruker AXS D8 Discover X-Ray diffractometer
- Leica Microsystems Inc. Vibration Isolation Table
- Ion Beam Thinner w/HP computer XLA/2000
- Struers LaboPol-5 Grinding/Polishing Machine, Qty 2

- Buehler 11-1280-160 Low Speed Saw
- GKM: RMC Glass Knife Maker
- D500i Dimpler
- Gatan 656 Dimple Grinder
- Buehler Versamet 3 Inverted Optical Microscope
- High Precision Balance
- Turbo Carbon Evaporator
- Gatan 691 Ion Beam Thinner
- Leica EM UC6b Ultramicrotome
- JEOL TEM Ion Slicer

Appendix B: Biographical Sketches

1. Kurtis Cantley

2. Amy Moll

Kurtis D. Cantley, PhD

Assistant Professor
Department of Electrical and Computer Engineering
Telephone: (208) 426-5715
E-mail: kurtiscantley@boisestate.edu

Boise State University
College of Engineering
1910 University Drive
Boise, Idaho 83725-2075

Education

Washington State University	Electrical Engineering	B.S., May 2005
Purdue University	Electrical and Computer Engineering	M.S., August 2007
University of Texas at Dallas	Electrical Engineering	Ph.D., December 2011

Appointments

July 2013 – present	Assistant Professor, Department of Electrical and Computer Engineering and Affiliate Faculty, Department of Materials Science and Engineering, Boise State University, Boise, ID
January 2012 – June 2013	Postdoctoral Research Associate, Department of Materials Science and Engineering, University of Texas at Dallas, Richardson, TX
August 2007 – December 2011	Graduate Research Assistant, University of Texas at Dallas, Richardson, TX (with National Defense Science and Engineering Graduate Fellowship 2007-2010)
August 2005 – July 2007	Graduate Research Assistant, Purdue University, West Lafayette, IN

Financial Support

Year	Title	Agency/Program	Role	Amount/Time
2014	2-D Crystals as an Extracellular Matrix for Cell/Neuron Growth and Differentiation	Boise State COBRE Pilot Grant	Co-PI	$49,991/1 year
2013	Spike Timing-Dependent Learning Circuits for Temporal Pattern Recognition and Classification	AFOSR Young Investigator Program (YIP)	PI	$359,429/3 years

Relevant Publications

1. J. W. Murphy, L. Smith, J. Calkins, G. R. Kunnen, I. Mejia, K. D. Cantley, R. A. Chapman, J. Sastra-Hernandez, R. Mendoza-Perez, G. Contreres-Puente, D. R. Alee, M. A. Quevedo-Lopez, and B. E. Gnade, "Thin film cadmium telluride charged particle sensors for large area neutron detectors," Applied Physics Letters, vol. 105, no. 112107, 2014.

2. A. Subramaniam, K. D. Cantley, and E. M. Vogel, "Logic Gates and Ring Oscillators based on Ambipolar Nanocrystalline-Silicon TFTs," *Active and Passive Electronic Components*, vol. 2013, no. 525017, 2013.

3. A. Subramaniam, K. D. Cantley, G. Bersuker, D. Gilmer, and E. M. Vogel, "Spike-Timing-Dependent Plasticity using Biologically Realistic Action Potentials and Low-Temperature Materials," *IEEE Transactions on Nanotechnology*, vol. 12, no. 3, pp. 450-459, 2013.

4. A. Subramaniam, K. D. Cantley, H. J. Stiegler, R. A. Chapman, and E. M. Vogel, "Low Temperature Fabrication of Spiking Soma Circuits Using Nanocrystalline-Silicon TFTs," *IEEE Transactions on Neural Networks and Learning Systems*, vol. 24, no. 9, pp. 1466-1472, 2013.

5. K. D. Cantley, A. Subramaniam, H. J. Stiegler, R. A. Chapman, and E. M. Vogel, "Neural Learning Circuits Utilizing Nano-Crystalline Silicon Transistors and Memristors," *IEEE Transactions on Neural Networks and Learning Systems*, vol. 23, no. 4, pp. 565-573, 2012.

6. P. G. Fernandes, H. J. Stiegler, M. Zhao, K. D. Cantley, B. Obradovic, R. A. Chapman, H.-C. Wen, G. Mahmud, and E. M. Vogel, "SPICE Macromodel of Silicon-on-Insulator-Field-Effect-Transistor-Based Biological Sensors," *Sensors and Actuators B: Chemical*, vol. 161, no. 1, pp. 163-170, 2012.

7. B. Chakrabarti, H. Kang, B. Brennan, T. J. Park, K. D. Cantley, A. Pirkle, S. McDonnell, J. Kim, R. M. Wallace, and E. M. Vogel, "Investigation of Tunneling Current in SiO_2/HfO_2 gate stacks for flash memory applications," *IEEE Transactions on Electron Devices*, vol. 58, no. 12, pp. 4189-4195, 2011.

8. K. D. Cantley, A. Subramaniam, H. J. Stiegler, R. A. Chapman, and E. M. Vogel, "Hebbian Learning in Spiking Neural Networks with Nano-Crystalline Silicon TFTs and Memristive Synapses," *IEEE Transactions on Nanotechnology,* vol. 10, pp. 1066-1073, 2011.

9. A. Subramaniam, K. D. Cantley, H. J. Stiegler, R. A. Chapman, and E. M. Vogel, "Submicron Ambipolar Nanocrystalline Silicon Thin-Film Transistors and Inverters," *IEEE Transactions on Electron Devices*, vol. 59, no. 2, pp. 359-366, 2011.

10. K. D. Cantley, A. Subramaniam, R. R. Pratiwadi, H. C. Floresca, J. Wang, H. J. Stiegler, R. A. Chapman, M. J. Kim, and E. M. Vogel, "Hydrogenated Amorphous Silicon Nanowire Transistors with Schottky Barrier Source/Drain Junctions," *Applied Physics Letters*, vol. 97, no. 14, 2010.

Professional Activities

Chair, "Flexible Electronics IV" (Conference 8730), SPIE Defense, Security, and Sensing 2013, Baltimore, MD.

Chair, 2012 IEEE International Midwest Symposium on Circuits and Systems (MWSCAS) Poster Session C1P-K, "Image Processing Applications"

Manuscript Review: *Journal of Applied Physics* and IEEE *Transactions on Nanotechnology*, *Transactions on Fuzzy Systems*, *Transactions on Neural Networks and Learning Systems*, *Electron Device Letters*

Proposal Review: 2015 NSF GRFP Review Panel, 2015 AFOSR YIP Proposal Reviewer, 2014 ASEE SMART Scholarship Review Panel

Service Activities

Idaho Microfabrication Laboratory Faculty Committee, 2013–present.

ECE Department Outreach and Recruiting Committee, 2014–present.

Boise State STEM Exploration Day: SnapCircuits and CircuitScribe Valentine Cards, 2015.

Boise State e-Day: Build an Electric Motor, 2014.

Collaborators

D. Estrada (Boise State); S. Jedlicka (Lehigh University); J. Browning (Boise State); K. A. Campbell (Boise State); E. M. Vogel (Georgia Institute of Technology); B. E. Gnade (University of Texas at Dallas); G. Bersuker (SEMATECH)

Amy J. Moll

Education

University of Illinois, Urbana, Ceramic Engineering, B.S., 1987
University of California at Berkeley, Materials Science & Engineering, M.S., 1992
University of California at Berkeley, Materials Science & Engineering, Ph.D., 1994

Appointments

2012 - **:** Dean, College of Engineering, *Boise State University*
2011-2012 **:** Interim Dean, College of Engineering, *Boise State University*
2010 – **:** Professor, Materials Science & Engineering, *Boise State University*
2004-2010 **:** Associate Professor, Materials Science & Engineering, *Boise State University*
2004-2008 **:** Chair, Materials Science & Engineering, *Boise State University*
2000-2004 **:** Assistant Professor, Mechanical Engineering, *Boise State University*
1999-2000 **:** R&D Project Manager, *Agilent Technologies*, Co. Springs, CO
1998-1999 **:** Process Engineering Manager**,** *Hewlett Packard*, Co. Springs, CO
1996-1998 **:** Production Manager**,** *Optoelectronics Div. Hewlett Packard,* San Jose, CA
1997-1998 **:** Adjunct Professor**,** *San Jose State University,* San Jose, CA
1994-1996 **:** R&D Engineer**,** *Optoelectronics Division. Hewlett Packard,* San Jose, CA
1989-1994 **:** Research Assistant**,** *Lawrence Berkeley National Lab.*, Berkeley, CA
1991-1994 **:** Teaching Assistant**,** *University of California*, Berkeley, CA
1987-1989 **:** Research Intern**,** *IBM Watson Research Laboratory,* Yorktown Heights, NY
1985-1987 **:** Laboratory Assistant**,** *Army Corp of Engineers,* Champaign, IL

Financial Support (current)

1. PERSIST: Promoting Educational Reform Through Systemic Transformation, National Science Foundation, $2,000,000, September 2013 – August 2017
2. Lead-It Yourself! Workshops, National Science Foundation, sub-contract from University of Washington, $24,936, December 2013 – November 2016
3. Noyce Phase II, Trajectory to Teaching from Recruiting to Career, National Science Foundation, $799,732, September 2013 – August 2016
4. Idaho Scholarships for Transfer Students, National Science Foundation, $598,025, August 2010 – August 2015.

Relevant Publications

1. Louis S. Nadelson, Anne Seifert, Amy J. Moll, and Brad Coats. "i-STEM Summer Institute: An Integrated Approach to Teacher Professional Development in STEM" Journal of STEM Education: Innovation and Outreach *13.2* (2012): 69-83
2. G. VanAckern, R.J. Baker, A.J. Moll, and V. Saxena "On-chip 3D Inductors using Thru-Wafer Vias", 2012 IEEE Workshop on Microelectronics and Electron Device, p. 20, 2012.
3. L.S. Nadelson, A.J. Moll, A.L. Seifert**,** *"Living in a materials world: Materials science and engineering professional development for K-12 educators"* ASEE Annual Conference and Exposition, Conference Proceedings, 118th ASEE Annual Conference and Exposition, 2011.
4. Megan Frary, Patrick Andersen, Mariela Bentancur, and Amy Moll, *"Microstructural Effects during Chemical Mechanical Planarization of Copper,"* Journal of the Electrochemical Society, **157** (1) H120-H126 (2010).
5. S.Y. Chyung, A. Moll, & S. Berg, "The Role of Intrinsic Goal Orientation, Self-Efficacy, and E-Learning Practice in Engineering Education," The Journal of Effective Teaching, 10(1), 22-37 (2010)

6. S.Y. Chyung, A.J. Moll, J. Callahan, M. Frary and B. Marx, "Improving Engineering Students' Cognitive and Affective Preparedness with a Pre-Instructional E-Learning Strategy," Advances in Engineering Education, **2**, 1-28 (2010).
7. D.L. Kellis, A.J. Moll and D.G. Plumlee, "Effects of silver paste application on embedded channels in low temperature co-fired ceramics", Journal of Microelectronics and Electronic Packaging, **6**, 54-58(2009)
8. Miller S, Pyke P, Moll A, Wintrow M, Schrader C, and Callahan J. "Successes of an Engineering Residential College Program within an Emerging Residential Culture." Proceedings of the 2009 ASEE Conference and Exposition, AC2009-1113.J.
9. J. Jozwiak, R.G. Southwick III, V.N. Johnson, W.B. Knowlton, and A.J. Moll, *"Integrating Through-Wafer Interconnects with Active Device and Circuits,"* IEEE Transactions on Advanced Packaging, **31** (1) 4-13 (2008)

Professional Activities

Member, Board of Directors, Discovery Center of Idaho
Member, National Cooperative Highway Research Program Transportation Research Board
Chair, Selection Committee, Tau Beta Pi Outstanding Advisor
Judge, Engineering Award Committee
Judge, Future City Competition

Service Activities

Chair, Search Committee, Dean, College of Education, Boise State University
Member, Search Committee, Associate VP of Human Resources, Boise State University
Co-Chair, Strategic Enrollment Academic Plan, Boise State University
Puppy-Raiser, Canine Companions for Independence
Chair of MRS Public Outreach Committee: technical advisors to: WGBH for four part NOVA series on Materials Science, NISE Net, DBIS,
Chair of Outreach Activities Committee and Member of Design Development Task Force for *Strange Matter*, a 5000 ft^2 traveling museum exhibit on Materials Science sponsored by the Materials Research Society.
Founding Chair, Materials Science & Engineering Program, Boise State University, 2004-2008: Developed an graduate minor (2000), undergraduate minor (2001), five new courses (2000-2002), an interdisciplinary degree program, (with Physics, Chemistry, Electrical Engineering & Mechanical Engineering) Master of Science in Materials Science & Engineering (2003) and undergraduate B.S. program (2004)

Collaborators and Other Affiliations

List of Collaborators (last 4 years)

S. Shadle (Boise State), P. Pyke (Boise State), T. Marker (Boise State), T. Roark (Boise State), E. Riskin (U of Washington), J. Yen (U. of Washington), L. Stauffer (U. of Idaho) W.B. Knowlton (BSU), J. Callahan (BSU), L. Nadelson (Utah State), D Plumlee (BSU)

Appendix C: Other – Scanned Letters of Support

1) Micron Technology Inc.

2) QTI Sensing Solutions

3) American Semiconductor

4) PakSense

5) BIT Bio Inspired Technologies

6) PKG User Interface Solutions

7) Western Electronics

8) NxEdge

9) MicroSil Silicon Services

April 22, 2015

Dr. Kurtis Cantley and Dr. Amy Moll
College of Engineering
Boise State University

Dear Dr. Cantley and Dr. Moll:

Expansion of the microfabrication and nanotechnology capabilities at Boise State will benefit Micron in a variety of ways. Micron has a strong partnership with the College of Engineering at Boise State evident from our support of the ECE and MSE PhD programs. Materials processing research and development in the areas of microfabrication and nanotechnology are our critical to our core business. Additional capabilities at Boise State can be utilized for special projects at Micron. For example, we utilized the e-beam lithography capabilities at Boise State when we were in the initial phase of exploring this technology. We have also directly supported research projects at Boise State in that use these facilities. Research projects in shape memory alloys and in DNA nanotechnology have both receive direct financial support from the Micron Foundation and we are a partner on a National Science Foundation grant in scalable nanomanufacturing.

Expanded processing capabilities are also critical to the education of Micron's next generation of engineering talent. We hire Boise State engineering students and support our employees to continue their education at Boise State through the graduate programs. Many of our employees would benefit from learning more about nanotechnology and microfabrication.

We are strongly supportive of this proposal and believe it will lead to increased economic development in the State of Idaho. We intend to actively support the expanded capabilities of the Idaho Microfabrication Laboratory will also designate a Micron employee from the appropriate area to serve on the advisory board. Please feel free to contact us if you need additional information.

Sincerely

Scott DeBoer
Vice President, Research and Development
Micron Technology, Inc.

Qti
Sensing Solutions
2108 Century Way Boise, Idaho 83709 USA
Tel: (208) 377-3373, 800-554-4784 Fax: (208) 376-4754
Email: qtisales@thermistor.com

April 22, 2015

Dr. Kurtis Cantley and Dr. Amy Moll
College of Engineering
Boise State University

Dear Dr. Cantley and Dr. Moll

QTI Sensing Solutions, was founded in 1977 as Quality Thermistor, Inc., to meet the increasing demand for high quality electronic components for the aerospace industry. Since then, QTI has exceeded the requirements of some of the most stringent high cost of failure applications, changing the landscape of the supply chain for the entire industry.

Today, QTI continues to maintain its leadership position for mission-critical applications as well as for medical and industrial applications by supplying the world's top companies with innovative products and services. In fact, QTI developed the highest standard for surface mount thermistors with the introduction of qualified surface mount parts to meet exacting military requirements.

QTI's is headquartered in Boise and our Idaho facility manufactures over 15 million thermistor components each year, supplying sensing elements for applications from spas to the Mars Rover. QTI-Boise also maintains a full thermistor test lab capable of performing a variety of stress and accelerated life testing for thermistors used in military and aerospace applications.

Expansion of the microfabrication and nanotechnology capabilities at Boise State will benefit QTI in a variety of ways. We have already developed a partnership with Boise State and have used both the processing and characterization capabilities. With the expanded capabilities for materials processing in the current proposal, we expect to increase our direct use of these facilities. Once the infrastructure upgrades and added equipment are in place, we expect to utilize approximately 20 to 25 hours per year of materials processing and characterization time in the Boise State facility. Sponsoring senior design projects and collaborative research projects are also of interest to us. Through this project we intend to provide as much as $5,000 to Boise State for these services and activities. Access to the expanded capabilities will allow us to explore new technologies and potentially lead to new products.

The expanded training opportunities are also of interest. Many of our employees would benefit from learning more about the nanotechnology and microfabrication. In addition, we are interested in hiring engineers who have a background in nantechnology. We will also provide time for one of our engineers or engineering managers to serve on the industrial advisory board.

We are strongly supportive of this proposal and believe it will lead to economic development in the State of Idaho. Please feel free to contact us if you need additional information.

Sincerely,

Brandon Coleman
General Manager

www.thermistor.com

American Semiconductor®
2230 S Cole Road Suite 130, Boise ID 83709
208.336.2773
www.americansemi.com

April 22, 2015

Dr. Kurtis Cantley and Dr. Amy Moll
College of Engineering
Boise State University

Dear Drs. Cantley and Moll

American Semiconductor, Inc. is the industry leader in flexible integrated circuits and flexible hybrid systems development. As our name implies, American Semiconductor is dedicated to U.S. manufacturing. All of our products and services are made and performed on-shore in the United States of America. We are a complete service provider for flexible ICs, from concept to fabrication. American Semiconductor offers a complete suite of engineering and manufacturing services that enable our customers to realize their products.

As an on-shore, ITAR compliant, flexible products and services provider, American Semiconductor supports all aspects of IC design, FleX Silicon-on-Polymer flexible wafer processing, and Flexible Hybrid Systems design & manufacturing. IC services include design, verification, layout, foundry selection, foundry management, and test. Engineering support for flexible hybrid systems includes printed electronics design and fabrication, antenna design and fabrication, FleX integration, prototype development, and production.

We strongly support Boise State University's IGEM proposal to expand facilities, equipment and expertise in the emerging research areas of flexible/printed electronics, thin-film and 2D materials including the addition of engineering faculty for these areas. We are already working with Boise State to establish a regional industrial capability for the newly emerging flexible hybrid electronics industry. We believe the proposed expansion at Boise State will improve opportunities for industrial partnerships and collaborations through direct access of local business to advanced facilities and research at Boise State.

The expanded training opportunities are also of interest and we are willing to provide one of our engineers or engineering managers to serve on the industrial advisory board. We are interested in collaborative research projects and senior design projects related to hybrid electronics that will prepare interns and new engineers for permanent positions at American Semiconductor. Additionally, our engineering employees could benefit from learning more about nanotechnology and microfabrication. We are strongly supportive of this proposal and believe it will lead to economic development in the State of Idaho. Please feel free to contact us if you need additional information.

Sincerely,

Douglas R. Hackler Sr.
President and CEO

FleX Silicon-on-Polymer | Flexible Hybrid Technology | Design Services

6223 N. Discovery Way
Suite 120
Boise, Idaho 83713 USA
+1 (208) 489-9010
www.paksense.com

April 22, 2015

Dr. Kurtis Cantley and Dr. Amy Moll
College of Engineering
Boise State University

Dear Drs. Cantley and Moll

PakSense is a market leader in the development of intelligent sensing products specifically designed to monitor perishable goods. We currently provide numerous major food retailers and suppliers with solutions to help monitor the condition of perishable items through the global supply chain. Having sold to more than 1,500 customers around the world, we have a proven track record in helping ensure that only the freshest and safest products reach consumers.

PakSense's current products are one-time use electronic time and temperature loggers optimized to monitor and record conditions at the container level for up to 90 days. We monitor all segments of the food supply chain including supplier to the retail distribution center, retail distribution center to the store, and perishable exports from around the world. Many food suppliers and processors also use PakSense Labels as a component of their internal quality assurance programs.

Expansion of the microfabrication and nanotechnology capabilities at Boise State will benefit PakSense in a variety of ways. We have already developed a partnership with Boise State and have used both their processing and characterization capabilities. With the expanded capabilities for materials processing in the current proposal, we are interested in additional ways to partner with Boise State. We are interested in sponsoring senior design projects and collaborative research projects and expect to hire interns and engineers from Boise State. Access to the expanded capabilities will allow us to explore new technologies and potentially lead to new products.

Boise State's expanded training opportunities are also of interest. Many of our employees would benefit from learning more about nanotechnology and microfabrication. In addition, we are interested in hiring engineers who have a background in nanotechnology. We will also provide time for one of our engineers or engineering managers to serve on the industrial advisory board.

We are strongly supportive of this IGEMS proposal and believe it will lead to economic development in the State of Idaho. Please feel free to contact me if you would like additional information.

Sincerely,

Casimir "Kaz" Lawler, Jr.
Chief Technology Officer

Bio Inspired Technologies

www.bioinspired.net

To whom it may concern,

We are providing this letter of support to Boise State University (BSU) and the pending IGEM proposal of Spring, 2015. Our company has been based in Boise, Idaho since 2010 and currently designs and develops adaptive intelligence products for both the unmanned aerial vehicle (UAV) and advanced computing architecture industries. We have successfully licensed memristor technology from BSU and are currently producing memristor based products for the military, academic, and research markets globally.

As a local startup high tech company, we are constantly in need of both advanced technology capabilities to drive our product lines and the engineering talent to design those product lines. At present, a significant amount of both of these is outsourced to areas outside of Idaho. While workable in its present state, we feel that the opportunity to bring both manufacturing lines and engineering talent back to the Treasure Valley is critical to the economic growth and an enhanced quality of life for Idahoans. We feel that key to this strategy is a well-equipped and highly enabled university team capable of working in tandem with local industry to both develop and support the transfer of ideas and technology. Additionally, we feel that direct support, made possible by the acquisition and support of high tech manufacturing equipment at the university and the accompanying infrastructure will provide a competitive advantage to our company. This competitive advantage results in increased sales, expanding product lines, and ultimately translates into high-paying technology jobs in the valley. The increase in hiring ability and the close interaction with a trained university team also results in opportunities for students at the university to fast-track into highly skilled and well-paying local technology jobs.

As a result, Bio Inspired Technologies strongly encourages support for BSU from the IGEM proposal because of the significant growth opportunities that added capability, in the form of equipment and resources can provide. The advantage created by such support will directly result in high quality local jobs and increased economic impact disproportional to the initial investment required, making this support a good investment for all of Idaho.

Best regards,

Terry Gafron - CEO
Terry.Gafron@bioinspired.net
208.585.8465

www.bioinspired.net

PKG
User Interface Solutions

April 22, 2015

Dr. Kurtis Cantley and Dr. Amy Moll
College of Engineering
Boise State University

Dear Drs. Cantley and Moll,

PKG User Interface Solutions is an industry-leading designer, developer and manufacturer of advanced, innovative user interface systems in the medical, industrial, avionics and instrumentations industries. PKG utilizes innovations in technology and collaboration among industry experts, while offering an unmatched, high-touch customer experience, to deliver competitive solutions for a vast array of customized user interface needs.

As a single-source solutions provider, PKG's engineering services range from concept development to technology selection, from electro-mechanical engineering to reliability testing, and from firmware development to software applications. From membrane switches to full-travel keyboards, from touchscreens to trackballs, from displays to pointing devices, and from silicone keypad to cables, PKG is fully equipped to integrate multiple technologies into a cohesive system—optimizing cost and quality.

Expansion of the microfabrication and nanotechnology capabilities at Boise State will benefit PKG in a variety of ways. We have already developed a partnership with Boise State and have used both the processing and characterization capabilities. With the expanded capabilities for materials processing in the current proposal, we are interested in additional ways to partner with Boise State. Senior design projects and collaborative research projects are also of interest to us. We regularly hire interns and engineers from Boise State. Access to the expanded capabilities will allow us to explore new technologies and potentially lead to new products.

The expanded training opportunities are also of interest. Many of our employees would benefit from learning more about the nanotechnology and microfabrication. In addition, we are interested in hiring engineers who have a strong processing background.

We are strongly supportive of this proposal and believe it will lead to economic development in the State of Idaho. Please feel free to contact us if you need additional information.

Sincerely,

Tiam Rastegar
Program Manager,

PKG, Inc. | 580 East Corporate Drive | Meridian, Idaho 83642 | P: 208-884-4900 F: 208-884-4949 | www.pkguis.com

April 22, 2015

Dr. Kurtis Cantley and Dr. Amy Moll
College of Engineering
Boise State University

Dear Drs. Cantley and Moll

Western Electronics is an award winning leader in Contract Electronics Manufacturing. We specialize in providing electronic manufacturing services primarily for the western portion of North America. Our niche in the EMS industry is low to medium volume production of complex assemblies with medium to high mix requirements. Our diverse customer base requires an exceptional level of quality, delivery, flexibility and responsiveness, while maintaining cost competitiveness. We offer a full range of EMS services including printed circuit board assembly, electro-mechanical assembly (box build), wire harness and cabling assembly, and end-order fulfillment.

Expansion of the microfabrication and nanotechnology capabilities at Boise State will benefit Western Electronics in a variety of ways. We have already developed a partnership with Boise State and have used both the processing and characterization capabilities. With the expanded capabilities for materials processing in the current proposal, we are interested in additional ways to partner with Boise State. Senior design projects and collaborative research projects are also of interest to us. We regularly hire interns and engineers from Boise State. Access to the expanded capabilities will allow us to explore new technologies and potentially lead to new products.

The expanded training opportunities are also of interest. Many of our employees would benefit from learning more about the nanotechnology and microfabrication. In addition, we are interested in hiring engineers who have a strong processing background.

We are strongly supportive of this proposal and believe it will lead to economic development in the State of Idaho. Please feel free to contact us if you need additional information.

Sincerely,

Name: William Casey
Title: Corporate Supplier Quality Engineer

April 22, 2015

Dr. Kurtis Cantley and Dr. Amy Moll
College of Engineering
Boise State University

Dear Drs. Cantley and Moll

NxEdge is a world class company with manufacturing facilities in Boise that provides vertically integrated solutions to the semiconductor market. Our expertise in engineering material coatings allows both global leading chip manufacturers and equipment makers to achieve next generation technologies with their products

Expansion of the microfabrication and nanotechnology capabilities at Boise State will benefit NxEdge in a variety of ways. We have already developed a partnership with Boise State and have used both the processing and characterization capabilities. With the expanded capabilities for materials processing in the current proposal, we are interested in additional ways to partner with Boise State. In the past we have sponsored senior design projects and collaborative research projects are also of interest to us. We regularly hire interns and engineers from Boise State. Access to the expanded capabilities will allow us to explore new technologies and potentially lead to new products.

The expanded training opportunities are also of interest. Many of our employees would benefit from learning more about the nanotechnology and microfabrication. In addition, we are interested in hiring engineers who have a background in nanotechnology. We will also provide time for one of our engineers or engineering managers to serve on the industrial advisory board.

We are strongly supportive of this proposal and believe it will lead to economic development in the State of Idaho. Please feel free to contact us if you need additional information.

Sincerely,

Nikolaos Xydas, PhD.
Director of Engineering & Quality

MicroSil
Silicon Services
530 N. Kings Rd. Nampa, ID 83687
Phone (208) 466-1930 Fax (208) 466-1939

April 22, 2015

Dr. Kurtis Cantley and Dr. Amy Moll
College of Engineering
Boise State University

Dear Drs. Cantley and Moll

MicroSil is a full-service silicon, sapphire, AlN, and innovative material substrate/wafer processing and reclaim facility in Nampa, Idaho. The company was founded in 1994 by engineers having extensive prior experience in semiconductor fabrication and related manufacturing. MicroSil has developed a number of proprietary processes and specializes in offering a variety of services to support individual needs.

Expansion of the microfabrication and nanotechnology capabilities at Boise State will benefit MicroSil in a variety of ways. We have already developed a partnership with Boise State and have used characterization capabilities. With the expanded capabilities for materials processing in the current proposal, we are interested in additional ways to partner with Boise State. Senior design projects and collaborative research projects are also of interest to us. Access to the expanded capabilities will allow us to explore new technologies and potentially lead to new products.

The expanded training opportunities are also of interest. Many of our employees would benefit from learning more about the nanotechnology and microfabrication. In addition, we are interested in hiring engineers who have a strong processing background.

We are strongly supportive of this proposal and believe it will lead to economic development in the State of Idaho. Please feel free to contact us if you need additional information.

Sincerely,

John Rule

John Rule, President
Microsil, LLC