COVER SHEET FOR GRANT PROPOSALS

State Board of Education

SBOE PROPOSAL NUMBER: (to be assigned by SBOE)	AMOUNT REQUESTED: $50,000

TITLE OF PROPOSED PROJECT:
Integral 3D Strain Sensor, Phase II

SPECIFIC PROJECT FOCUS:

We develop a prototype sensor based on a novel material technology offering potentially disruptive engineering advancement. Our commercialization plan foresees deploying the sensor in tires of earth moving equipment where our technology addresses a costly problem affecting regional industry without solution.

PROJECT START DATE: 7/1/14	PROJECT END DATE: 6/30/15
NAME OF INSTITUTION: Boise State University	DEPARTMENT: Office of Sponsored Programs
ADDRESS: 1910 University Dr., Boise, ID 83725-1135	
E-MAIL ADDRESS: osp@boisestate.edu	PHONE NUMBER: 208-426-4420

	NAME:	TITLE:	SIGNATURE:
PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR	Dr. Peter Mullner	Professor & Department Chair	
CO-PRINCIPAL INVESTIGATOR	Dr. Nader Rafla	Associate Professor	

NAME OF PARTNERING COMPANY:	COMPANY REPRESENTATIVE NAME:
Gryphon Business Consultants MP Research	Jessica Mutch Dr. Paul Lindquist

	NAME:	SIGNATURE:
Authorized Organizational Representative	Karen Henry	

PROPOSAL NARRATIVE: INTEGRAL 3D STRAIN SENSOR, *PHASE II*

1	IDAHO PUBLIC INSTITUTION	Boise State University
2	PROJECT DIRECTOR (PI), PROJECT TEAM	PI: Peter Müllner, Materials Science & Engineering Department Co-PI: Nader Rafla, Electrical and Computer Engineering

3. Previous Proposal for Incubation Fund

Last year, our project team submitted a proposal and received $45,750 from the FY 2014 HERC Incubation Fund (*Grant IF14-005*). Our aim was to complete research leveraging ***Magnetic Shape Memory Alloy (MSMA)*** technology which we will use to ultimately develop and commercialize a 3D strain sensor. During this one-year *Phase I* effort, our objectives were to:

a) Develop a MSMA/elastomer composite transducer material as basis for a sensor device

b) Develop a drive/detect coil system with control electronics.

c) Demonstrate 3D sensor functions.

We have nearly completed *Phase I*, having successfully achieved goals a) and b) and are making good progress towards goal c). As forecast in last year's proposal, *Phase II* will build on *Phase I* outcomes. This *Phase II* current proposal is not a project extension addressing any of the prior objectives, but a new proposal to build and test a 3D Strain Sensor ***prototype***.

4. Executive Summary

Magnetic Shape Memory (MSM) technology offers a potentially disruptive engineering advancement. It presents a new way to make motors, pumps, sensors, and other products that potentially offer real economic opportunity for the state of Idaho. This technology would enable manufacturers to greatly simplify and miniaturize products—eliminating parts and friction that cause wheels, gears, and shafts to fail at small scales. In traditional engineering, a machine is made of interconnected parts, each part is a static object, but the machine moves to carry out a single function. Interlinked parts enable the machine to perform as a whole. In contrast our team

uses magnetic fields to deform MSMA material in the device, creating "shape shifting" materials manufacturers can use to build machines to operate without rotational motion. For example, localized contraction and expansion of a bar within a motor could make it bend like an elbow.

To further enhance this technology, we seek to incorporate a novel 3D strain sensor into the material itself. Doing so would enable manufacturers to monitor material performance over time. Traditional pressure sensors measure a single force component—a downward push, for instance. But machines are three dimensional objects, with forces up, down, and around enabling machine operation and sometimes limiting performance. For this *Phase II* proposal, we will develop a sensor that uses a change in magnetic permeability to identify all six strain components in the MSMA/elastomer composite material we developed during *Phase I*. We have recently filed a patent for this concept (*Boise State file number 92*). In addition, the sensor will include a local non-volatile storage and wireless transceiver. This will extend sensor capability by enabling users to communicate strain information to a wide variety of wireless devices.

To complete this work, the research team is partnering with Gryphon Business Consultants (Boise, ID) — a group we identified in last year's proposal. This year, we are also adding the start-up company MP Research (Boise, ID). Our 3D sensor commercialization plan with anticipated completion dates is to (1) demonstrate functionality (12/2014), (2) build prototype (8/2015), (3) integrate sensor into pilot device (8/2016), (4) develop license agreement, and (5) manufacture first products (8/2017).

5. "Gap" Project Objective and Total Amount Requested

Our team has three project objectives. First, we will:

1. Build and test a prototype 3D strain sensor
    a) *Optimize MSMA/elastomer composite transducer material*

b) *Demonstrate 3D sensor function*

c) *Demonstrate the 3D sensor prototype*

2. Find an Idaho industry partner to use the MSM technology in a manufactured product.

In addition, while developing the sensor material as the first objective for our FY14 project, we identified a significantly less expensive way to manufacture potential products leveraging MSMA materials. Since doing so would greatly reduce commercialization cost barriers, we would like to include further research on this method to Phase II research. We can develop the sensor from magnetic shape memory crystals grown in the lab at $30–50 per gram, or using our composite material, at $10 per gram. Therefore, our third objective is to:

3. Develop economical actuator (motor) material based on Ni-Mn-Ga/polymer composites.

6. Alignment Between Boise State Priorities and Committed Resources

This project aligns with Boise State research priorities. The university lists five research strengths/priorities (http://research.boisestate.edu/areas-of-research-strength-at-boise-state-university/) including (1) ***Novel Materials***, (2) ***Sensor Development***, (3) ***Nanoelectronics and Integrated Systems***, (4) Geochemistry and Geophysics, and (5) Health, Public and Energy Policy. The proposed is unusual in that it addresses three of the five institutional priorities by advancing novel materials, developing a sensor, and building an integrated system.

7. Evidence of Potential Impact to Idaho Economy

The MSMA technology, availability of a trained workforce, and access to ongoing international MSMA research suggest the potential for a real impact to Idaho's economy. We believe this project will help to launch a new industry in Idaho.

During the past ten years, close to forty undergraduate and graduate students have worked in the Magnetic Materials Laboratory with Dr. Müllner and received in-depth training on MSMA

technology. Many graduates prefer Treasure Valley employment over other places in the US, and stay in the region. With such a large number of experienced students and graduates, the Treasure Valley maintains one of the largest concentrations of MSMA expertise worldwide. Boise is thus the right place to launch a business leveraging MSMA technology.

In addition, Dr. Müllner collaborates with many international, leading scientists in the field in about ten countries. These contacts ensure sustaining new research development with cutting edge know-how. For example, two faculty from China and Poland are currently visiting Boise State and will spend a 15 months here. They are introducing our group to magnetocalorics, a hot research topic that aims to facilitate environmentally friendly refrigeration technologies.

The 3D strain sensor project is one technology commercialization initiative of a series of further technology development efforts at Boise State, among them a MSM-based pump for micro-fluidics applications (lab-on-the-chip, insulin pump, medical research), and four-state memory and energy harvesting (see also section 9c).

8. Market Opportunity

a. Need the project addresses: The proposed 3D sensor can improve performance by detecting when products may fail. For example, the performance and lifetime of elastic materials in tires, seats, clothes, shoes, floors, and buildings depends on variable loading conditions, wear, and other extrinsic factors. Material failure can initiate substantive product and health damage, and sometimes even fatalities. Monitoring elasticity over time can prevent damage, accurately predict the end of useful product life, and provide users with healthier car seats and workplace furniture. There is currently no device on the market with the capacity to measure more than one strain component; the 3D sensor will detect six. Furthermore, existing sensors measure strain

externally. Our technology is embedded internally as an integral part of the material.

b. Applications and markets for the technology, market size, and demand: The car industry presents a potentially multi-billion dollar market: in-cushion sensors can increase driver and passenger comfort, and impact and tire sensors can accurately predict remaining useful product life. As resources are becoming scarcer, demand for technology that optimizes product life will increase. Other markets include the health sector, office furniture, and haptics technology.

c. Product, market audience, competition, and barriers to market entry: The product is an Integral 3D Strain Sensor. The market audience includes users of complex and/or daily use products and machines where the impact of material failure can be significant or even dire: car owners, operators of earth moving businesses such as open pit mines, tire manufacturers, developers of airplane wheels, etc.

Nevertheless, despite technology potential, it's very novelty presents a market barrier. To overcome this barrier, we selected a market entry arena to address a costly problem affecting regional industry and with no solution — tire failure for large earth-moving equipment. The Intermountain West is home to several large and medium mining companies that use hauling trucks with specialized giant tires costing $100,000 each. Premature tire failure presents a major cost and risk to human life and equipment, and can result in down time and collateral damage. Mine operators and equipment vendors seek a solution, and high investment and damage costs motivate the industry to explore novel solutions. We identified this market in 2012 as an outcome of student research team analysis in a Boise State College of Business MBA course.

9. Technology and Path to Commercialization

a. Technology and current state of technology: MSMAs are multi-functional materials with advantages that introduce a new paradigm in mechanical engineering at small scale. A strong

coupling between magnetic and structural order leads to a very large magnetic-field-induced strain (MFIS). Compared to other actuators (motors), for example, MSM actuators offer several benefits: (1) up to 100 times longer stroke than piezo materials often used for actuators, (2) fast response, (3) large work output, (4) high position accuracy, (5) high dynamic range, (6) low power consumption, and (7) simpler and more reliable product performance.

3D Strain Detector. The proposed 3D detector consists of an elastomer-MSM composite as transducer (cube in ***Fig. 1***), three sets of coils (1, 2, 3) and an elastomer casing. As we have demonstrated, functionality mirrors the standard 1D sensor except that here we can measure inductance in three directions, i.e. coil sets 1, 2, and 3 provide the normal strains in *x*, *y*, and *z* direction. The composite material was demonstrated in *Phase 1*, the first project year.

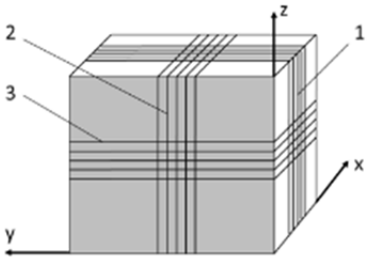

Figure 1: MSMA-based 3D sensor consisting of a transducer composite material (cube), and three sets of coils (1, 2, 3).

b. How the technology contributes to product and market need; intellectual property status: 3D sensors use stress-strain relationships to measure externally applied forces in three dimensions. The sensors are small (less than $1cm^3$) and could be used in many research fields and industry applications such as in the tire sensor noted earlier. Dr. Müllner and collaborators have obtained four patents on MSM technology, with five additional patent applications pending in arenas including and extending beyond 3D Strain Sensors. In addition, Boise State began negotiating a MSM energy harvesting technology licensing agreement on May 29, 2014.

c. Who developed the technology and with what funding: Drs. Müllner, Ullakko, and Sasaki developed this technology, all employed at Boise State at the time of invention. The team used university funds to demonstrate the invention.

d. Concrete steps to bring technology to market: already undertaken

DATE	ACTION
May 4, 2011	Conceived invention
June 2011	Demonstrated proof of concept
July 7, 2011	Disclosed invention to Boise State Office of University and Industry Venture
October 2011	Filed provisional patent on 3D sensor
Sept. 2, 2012	Contacted Gryphon Business Consultants (GBC)
October 15, 2012	Filed utility patent on 3D sensor
Fall 2012	Five student teams explored markets for MSM intellectual property.
January 11, 2013	Worked with GBC to transfer MSM technology to marketplace; worked with potential corporate partners to identify marketing opportunities
May 31, 2013	Met with Brad Roberts of Intellectual Venture discussing MSM technology
June 5, 2013	Organized business development event with 15 scientists, 5 representatives of companies producing MSM crystals, and GBC
Fall 2013	Established MSM-Net, an international network with industry representation to network between academy and industry
October 2013 to January 2014	Worked with representatives of four businesses in the Treasure Valley towards submitting development proposals
January 2014	Submitted a proposal with partners Teton Machine Co (Payette, ID) and WestVet (Boise, ID) to the NSF program *Partnership for Innovation: Building Innovation Capacity*
April 2, 2014	Submitted a proposal to NASA with NASA collaborators to develop MSM devices for space flight; long-term goals include developing manufacturing for space flight devices in Idaho
April 13, 2014	Submitted letter of intent to the Walmart Foundation requesting $2.4 million to develop MSM industry in Idaho
May 5, 2014	Incorporation of MP Research LLC by Dr. Paul Lindquist
May 29, 2014	Discussed license agreement and funding opportunities with company active in the renewable energy business; next meeting in August 2014
June 2, 2014	Received invitation to submit full proposal to the Walmart Foundation

Here are future steps towards bringing the technology to market.

DATE	ACTION
June 25, 2014	Hold MSM-Net kick-off meeting in Bremen, Germany
August 2014	Demonstrate 1D composite sensor functions
December 2014	Demonstrate 3D sensor functions
August 2015	Build prototype for Integrated 3D Strain Sensor
August 2016	Integrate sensor in pilot device (e.g., tire)
October 2016	Develop license agreement with industry partner
August 2017	Put product into production by August 2017

10. Commercialization Partners

We have two commercialization partners: (1) Gryphon Business Consultants (GBC), specializing in new business development and with more than 20 years' experience in industrial technologies, and (2) MP Research LLC, a new Idaho start-up.

On June 5, 2013, we organized a business development event as part of the 4th International Conference on Ferromagnetic Shape Memory Alloys, ICFSMA'13, in Boise, ID, June 3–7, 2013. As an outcome, Dr. Müllner, in collaboration with industry partner *ETO Magnetic* in Germany, launched the network MSM-Net. The purpose of this network is to connect researchers and industrial developers and bringing our technology to the market. This June 25, we will hold the member kick-off meeting in Bremen, Germany. To date, potential industrial partners include regional mines such as Nevada's Barrick Gold and Baker Hughes Barite mines as well as tire companies such as Goodyear and Colorado Tire Corporation.

Dr. Paul Lindquist, Assistant Research Professor in Dr. Müllner's research group, incorporated *MP Research LLC* in May 2014. Regarding MSM, MP Research's focus is to commercialize the actuator/sensing element by processing the alloys as powders or fibers in order to shrink its size. The main advantage of this approach is that it will potentially significantly reduce the cost of individual MSMA elements and the time needed to produce an element. MP Research will build proof-of-concept prototypes of sensors and actuators. MP Research is also seeking partners to manufacture prototypes at high volume scale.

Our team will meet weekly with Dr. Lindquist to coordinate technology development and to pursue funding opportunities, for example through National Science Foundation SBIR/STTR.

11. Specific Project Plan and Detailed Use of Funds

For the *Phase II* project year, our team will optimize the composite transducer material, demonstrate 3D strain sensor functions, and demonstrate a prototype 3D strain sensor.

a. Optimize MSMA/elastomer composite transducer material: We have demonstrated powder particles with sufficiently low switching field of 200 mT (we defined < than 300 mT as the 2013 proposal criterion). We demonstrated the sensing capability of particles in the composite via x-ray diffraction experiments. The sensing signal was weak, indicating that the underlying "twinning operation" was partial. We will optimize the composite material for high sensing capability by adjusting polymer stiffness and the particle volume fraction. As we optimize composite material sensing capacity, we will also advance its capability as an actuator material.

b. Demonstrate 3D sensor function: We demonstrated the sensor function with a single crystal transducer and one set of coils: a drive coil and a pick-up coil. ***Fig. 2*** shows the electrical schematic of the 3D sensor. Our team must measure the induced voltage of three coils simultaneously to determine all six strain components. We will use an encoder and a microcontroller to determine the distortion of the sample in each direction. The drive coils are activated using a 40kHz sine wave with amplitude of 100 mV. To remove noise from the signal in the pick-up coils, we will apply a band pass filter to the signal before measurement. The data acquisition (DAQ) sampling rate must be much greater than the frequency of the excitation signal so that the measured root mean square (RMS) value and signal reconstruction is accurate. Using DAQ sampling points, we will reconstruct the waveform and calculate RMS assuming a

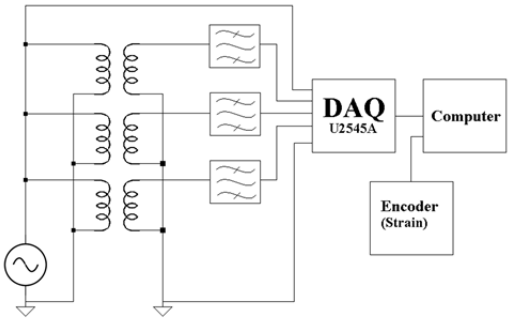

Figure 2: Electrical schematic of MSMA-based 3D sensor

sine wave. This RMS value is related to the strain. We will demonstrate this scheme with an optimized Ni-Mn-Ga/polymer composite material as transducer.

c. Demonstrate the 3D sensor prototype: In the second half of this *Phase II* effort, we will build a sensor prototype using the Ni-Mn-Ga/polymer transducer material, three sets of coils, a drive electronic set-up, a sensing electronic system, a data acquisition board, and data display device.

Detailed *Phase II* Use of Funds

ITEM	FUNDS ($)
Salaries (1/4 month for PI and co-PI, 3/4 stipend for graduate student and undergraduate student) plus fringe benefits	33,650
Materials and supply (raw materials, parts, small devices such as a furnace, processor, gas, consumables)	3,500
Fees for materials characterization (120 hours XRD/SEM at $35.00 per hour)	4,200
Travel for meetings with industry partners	600
Publication costs	300
Student costs (3/4 tuition)	7,750
Total amount requested	**$50,000**

12. Institutional and Other Sector Support

Boise State University's commitments towards this project include:

a. Fully equipped laboratories (Appendix 1)

b. Filing a patent "Sensor Device" in October 2012

c. Exploring the potential market through the MBA executive program (Fall 2012)

d. Hiring a PhD student for this project since June 2013, with up to 50% institutional funds

e. Hiring an undergraduate student familiar with the sensor since fall 2013

f. Paying approximately 10% time of an assistant research professor

g. Facilitating Dr. Paul Lindquist in spinning-off the company MP Research in May 2014

h. Providing travel support to attend the MSM-Net meeting in Bremen, June 25, 2014

i. Supporting 25% of a graduate student stipend with $9,000 per year (including tuition and benefits, resources of Department of Materials Science and Engineering) for FY 2015

FACILITIES AND EQUIPMENT

Most of the equipment is available in the 1600 square foot **Magnetic Materials Laboratory** of the PI, the **Boise State Center for Materials Characterization** (BSCMC, located in the College of Engineering http://coen.boisestate.edu/bscmc/index.htm), the **Idaho Mircrofabrication Laboratory** (IML, located in the College of Engineering http://coen.boisestate.edu/IMFL/index.html).

The instruments at BSU include

- Sputter deposition system with co-sputter (2 targets) and reactive sputter capability.
- Two AFM (Veeco Dimension 3100 Atomic Force Microscopy System and Veeco PicoForce Multimode Atomic Force Microscopy System) with dedicated software for analyzing phase, amplitude and height and MFM and nanoindenter functions. The system also includes harmonics imaging and in-situ heating-cooling capabilities.
- Scanning electron microscope -- LEO 1430VP with energy-dispersive X-ray spectroscopy (EDS) capability, electron beam lithography (EBL), electron backscatter diffraction (EBSD).
- Transmission electron microscope JEOL 2100 LaB_6, with scanning transmission electron microscopy capabilities, EDS, EELS, and magnetic domain imaging.
- x-Ray diffractometer Bruker D8 Discover with variable temperature up to 1600ºC, texture capabilities, thin film reflectometry, phase analysis, and HiStar area and scintillation detectors.
- Optical microscope -- Zeiss Axiovert 200 MAT with CCD camera and software.
- Optical microscope – MEIJI MT7100 with OPTIXCAM camera.
- High-resolution optical camera INFINITY with 21 megapixel resolution and video capability.
- High-sensitive Vibrating Sample Magnetometer (VSM) -- ADE model 10 with maximum field 2 T and heating/cooling capabilities for the temperature range from -100°C to 150°C.
- Variable temperature probe station for electrical measurements between 5.5 K and 450 K.
- Advanced electrical characterization systems (attoampere and microvolt resolution) -- Keithley 4200 Semiconductor Characterization System Keithley 595 Quasistatic Capacitance-Voltage Meter, HP 4284A LCR meter, Keithley 707A Ultra Low Current-High Frequency Solid State Switching Matrix (2-8X24 I/O cards), Agilent 81110A Pulse/Pattern Generator Unit (2 channels - frequency range up to 330MHz), Agilent Infiniium 54832D 1GHz 4 channel 4GSamples/s Mixed Signal Oscilloscope.
- Multibeam optical system of k-Space for substrate curvature measurements for temperatures up to 1,100°C. Separate temperature reading system “BandiT” for temperature reading up to 600°C.
- 1A power supply, platinized titanium anodes, beakers, hot plate, exhaust hood used for electrochemical deposition of thin films on conductive substrates.
- High-precision wire saw.
- Induret casting furnace for the fabrication of sputter targets and ingots.
- Pumping system to evacuate samples in a quartz glass tube and to flush the tube with inert gas such as argon.
- Tube furnaces.
- Beowulf-Cluster (130-processor Beowulf parallel computer-cluster user facility at BSU).

- Software: Mathematica, LabView, Modelsim & Cadence.
- Function / Arbitrary Waveform Generator, (HP_Agillent 33250) offers a full set of functions and waveforms with 12 bit resolution and a 200 MS/s sampling rate.
- Agilent MSO7034B Mixed Signal Oscilloscope. 350 MHZ with 4 analog plus 16 digital channels, 8 Mpts responsive deep memory, and 2 GSa/s sample rate
- Agillent E3631A 80W triple output: 0 to 6 V and 0 to ± 25V

The facilities of the PI further include student office space with 13 desks and computers with internet access.

Peter Müllner

Professional Preparation

ETH Zürich, Swiss Fed. Inst. of Tech., Zürich, Mater. Eng., Diploma (M.S.), 1991
ETH Zürich, Swiss Fed. Inst. of Tech., Zürich, Mater. Eng., Dr. sc. techn. (Ph.D.), 1994

Appointments

2013-pres. Chair, Materials Science and Engineering, *Boise State University*, Boise, ID; directing MSE undergraduate and graduate programs with 160 students and 13 faculty

2012 Visiting Professor, Physics, *University of Vienna*, Austria; guest lecturing for summer school

2012-pres. Distinguished Professor, *Boise State University*, Boise, ID; honorary position held by less than 5% of internationally recognized BSU faculty

2011-pres. Foundational Studies Program Faculty, *Boise State University*, Boise, ID; teaching a course "Invention and Discover in History and Society" to 200 first year students each semester

2009-pres. Professor, Mater. Sci. & Eng., *Boise State University*, Boise, ID; leading a research group of more than 10 students plus a research faculty with research focus multifunctional magnetic materials; teaching in the MSE program

2006-2011 Director, Boise State Center for Materials Characterization, *Boise State University*, Boise, ID; running a recharge center

2004-2009 Associate Professor, Mater. Sci. & Eng., *Boise State University*, Boise, ID; leading a research group of more than 5 students with research focus multifunctional magnetic materials; teaching in the MSE program

1998-2004 Senior Researcher**,** *ETH Zürich, Inst. of Appl. Phys.*, Zürich, Switzerland; leading a research team of 2-3 students with research focus magneto-mechanics

1996-1998 Research Associate**,** *Max-Planck-Inst. fur Metallforsch.*, Stuttgart, Germany; leading a research team of 2-3 students with research focus on metal thin films

1995 Post-doctoral Researcher**,** *University of Illinois*, Urbana, IL; conducting research projects

Products: 133 published articles, 4 patents granted, 4 patents pending, h-index 22

Selected publications (closely related to proposal)

1) C. S. Watson, C. Hollar*, K. Anderson*, W. B. Knowlton, P. Müllner, "*Magnetomechanical Four-State Memory*", Advanced Functional Materials (2013) 201203015.
2) K. Ullakko, L. Wendell, A. Smith*, P. Mullner, G. Hampikian, "*A magn. shape mem. micropump: contact-free, and compatible with PCR and human DNA profiling*", Smart Mat. Str. **21** 115020 (2012).
3) D. Kellis, A. Smith*, K. Ullakko, and P. Müllner, "*Oriented single crystals of Ni-Mn-Ga with very low switching field*", Journal of Crystal Growth 359 (2012) 64-68.
4) A. Rothenbühler, E. Barney Smith, P. Müllner, "*Appl. of image processing to track twin boundary motion in magnetic shape memory alloys*", Proc. SPIE Electronic Imaging- Image Processing: Machine Vision Applications V, Burlingame, CA, Vol. 8300. January 25, 2012. Paper 8300-0A.

5) D. C. Dunand and P. Müllner, "*Size effects on magnetic actuation in Ni-Mn-Ga shape-memory alloys*", Advanced Materials, **23** 216-232 (2011).

Synergistic Activities

- Chair of the ICFSMA'13 conference, June 3-7 2013, Boise ID, which is the main forum for the MSMA community.
- Foundational Studies Program Faculty since 2011; teaching a university foundations UF100 course for all incoming students; the course is entitled "Invention and Discovery in History and Society".
- Chairing and organizing international symposia/workshops including the symposium "Magnetostrictive and Magnetic Shape Memory Materials" at Actuator 2014, June 23-25, 2014, Berlin, Germany; the ICFSMA'13 conference, June 3-7 2013, Boise ID; MRS Spring Symposium Z "Materials Structures – The Nabarro Legacy", San Francisco, March 25, 2008 and Guest Editor for *Progress in Materials Science*, Vol. 54, Issue 6, Elsevier August 2009 Special Issue "The Nabarro Legacy – Perspectives for advanced materials in the 21st century"; and the international workshop 'Magnetic Shape Memory Alloys', Ascona, Switzerland, September 11-16. 2005.
- Director of the Boise State Center for Materials Characterization since 2006-2011.
- Organization and instruction of tutorials and teaching workshops including "Magnetic Shape Memory Alloys" at the MRS Fall Meeting 2009, Boston, MA; and the advanced training course 'Materials Science of Thin Films' of the German Society of Materials, Stuttgart.

Current Support

Sponsor	Project Title	Amount	Project Period	Months Committed
NSF	Materials World Network: Deformation via the Transformation of Hierarchical Microstructures	$480,000	8/15/10–7/31/14	.6 months
DOE	Fracture Mechanisms and Fatigue of Magnetic Shape-Memory Alloys	$456,000	7/15/11–7/14/14	1 month
NSF	Mechanics of Magnetic Shape-Memory Nanostructure	$400,000	9/15/11–8/31/14	.4 months
NSF	MRI: Acquisition of a GPU-accelerated High Performance Computing and Visualization Cluster	$555,384	10/1/12–9/30/14	0 months
NSF	Collaborative Research: Size Effects on Magneto-mechanics of Ni-Mn-Ga Fibers	$346,345	7/15/12–6/30/15	.5 months
Idaho Board of Education	Integral 3-D Strain Sensor	$45,750	7/1/13–6/30/14	.2 months
NSF	REU Site: Materials for Energy and Sustainability	$320,000	3/1/14–2/28/17	0 months
Micron Foundation	Microfluidic devices based on MSM technology	$50,000	7/1/14–6/30/15	0 months

Nader I. Rafla

PROFESSIONAL PREPARATION:

Helwan University, Cairo, Egypt,	BSEE,	1978
Case Western Reserve University, Cleveland, Ohio	MSEE,	1982
Case Western Reserve University, Cleveland, Ohio	Ph.D.,	1991

APPOINTMENTS:

2011 – Present	Associate Professor and Graduate Coordinator, Electrical and Computer Engineering Department, Boise State University, Boise, Idaho
2010 – 2011	Chair, Electrical and Computer Engineering Department, Boise State University, Boise, Idaho
1991 – 2010	Associate Professor, Electrical and Computer Engineering Department, Boise State University, Boise, Idaho
1991 – 1997	Assistant, Associate Professor, Manufacturing Engineering Department, Central State University, Wilberforce, Ohio

OTHER RELATED APPOINTMENTS:

Summer 2011 General Chair, 55th IEEE International Midwest Symposium on Circuits and Systems (MWSCAS2012), Boise ID. **Duties**: manage all arrangements for hosting the symposium along will all its technical aspects

Summers 2002 – 2007 R&D Scientist and Consultant, ASCI, Inc., Boise ID. **Duties:** Manage a team of engineers, graduate, and undergraduate students to develop Intellectual Property (IP) Hardware using HDL for different aspects of digital image caption, generation, transmission, and display.

MOST RELEVENT PUBLICATIONS

1. Nader Rafla and Nick Pauly, " An Automated embedded system for Object Measurement," *Proceedings of the International Midwest Symposium on Circuits and Systems, 8/2013*
2. Rafla, Nader I., "Teaching Digital Systems Verification Methodologies Using SystemVerilog," *118th ASEE Annual Conference and Exposition, Vancouver, BC, Canada, 6/2012*
3. Wald, Steve; Baker, R. Jacob; Mitkova, Maria I.; and Rafla, Nader I., "A Non-Volatile Memory Array Based on Nano-Ionic Conductive Bridge Memristors," *IEEE Workshop on Microelectronics and Electron Devices (WMED), Piscataway, NJ 4/2011*
4. Rafla, Nader and Gauba, Deepak, "Hardware Implementation of Context Switching for Hard Real-Time Operating Systems," *Proceedings of the 54th IEEE International Midwest Symposium on Circuits and Systems, 8/2011*
5. Nader Rafla and Indrawati Gauba "A Reconfigurable Pattern Matching Hardware Implementation using On-Chip RAM-Based FSM" *Proceedings of the 53rd IEEE International Midwest Symposium on Circuits and Systems, 8/2010*
6. Nader Rafla, and Sarath Giri, "A Programmable Pattern Generator for Memory Testing on a Programmable Chip," *IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems, February 2010*
7. Nader I. Rafla and Steve Bard, "Reducing Power Consumption in FPGAs by Pipelining," *Proceedings of the 51st IEEE International Midwest Symposium on Circuits and Systems (MWSCAS), Knoxville, TN, 8/2008*

SYNERGISTIC ACTIVITIES

- Participated in grant proposal review for NSF/CCLI Proposals - 2009;
- Active member of the Steering Committee of the IEEE/MWSCAS conference since 2005.
- General Chair of the IEEE/MWSCAS conference for 2012 in Boise, Idaho;
- Technical Editor, Analog Integrated Circuits and Signal Processing Journal for MWSCAS2012
- Technical Reviewer for IEEE Transaction on Computers, Image Processing, Parallel & Distributed Systems;
- Reviewer, ASEE Computers in Education Journal and the ASEE general conference;
- Member of the American Society for Engineering Education (ASEE);
- Senior Member of the Institute of Electrical and Electronic Engineering (IEEE), computer society, and Circuits and Systems Society;
- Recipient of several teaching rewards;
- Currently supervising 3 Ph.D. Dissertations, 5 MSEE Thesis, and on Graduate Thesis Committee for 3 students.

RECENT COLLABORATORS:

Peter Müllner (MSE), Kotaro Sasaki (ME), Tim Andersen (CS), Maria Mitkova (ECE), Elisa Barney Smith (ECE), Said Ahmed-Zaid (ECE) at Boise State University; Maher Rizkalla (EE) at Indiana University Purdue University (IUPUI) at Indianapolis; William Grissom (MFE), Abayomi A. Majebi (MFE), and Augustus Morris (MFE) at Central State University, Wilberfrce, Ohio; Steven Parke (ES) at Northwest Nazarene University, Idaho; Susan Burkett (MSE) at University of Alabama.

LIST OF CURRENT GRANTS:

Dr. Nader Rafla
Title: Integral 3-D Strain Sensor
Sponsor: Idaho State Board of Education
Project Period: 3/1/14 – 2/28/17
Amount: $45,750
Effort: 0.2 month

Peter Müllner

Professional Preparation

ETH Zürich, Swiss Fed. Inst. of Tech., Zürich, Mater. Eng., Diploma (M.S.), 1991
ETH Zürich, Swiss Fed. Inst. of Tech., Zürich, Mater. Eng., Dr. sc. techn. (Ph.D.), 1994

Appointments

2013-pres. Chair, Materials Science and Engineering, *Boise State University*, Boise, ID
2012 Visiting Professor, Physics, *University of Vienna*, Austria
2012-pres. Distinguished Professor, *Boise State University*, Boise, ID
2011-pres. Foundational Studies Program Faculty, *Boise State University*, Boise, ID
2009-pres. Professor, Mater. Sci. & Eng., *Boise State University*, Boise, ID
2006-2011 Director, Boise State Center for Mater. Charact., *Boise State University*, Boise, ID
2004-2009 Associate Professor, Mater. Sci. & Eng., *Boise State University*, Boise, ID
1998-2004 Senior Researcher**,** *ETH Zürich, Inst. of Appl. Phys.*, Zürich, Switzerland
1996-1998 Research Associate**,** *Max-Planck-Inst. fur Metallforsch.*, Stuttgart, Germany
1995 Post-doctoral Researcher**,** *University of Illinois*, Urbana, IL
1991-1994 Research Assistant**,** *ETH Zürich, Inst. of Appl. Phys.*, Zürich, Switzerland
1991-1994 Teaching Assistant**,** *ETH Zürich, Inst. of Appl. Phys.*, Zürich, Switzerland
1990 Research Internship**,** *Alusuisse-Lonza Services AG*, Neuhausen, Switzerland
1988 Research Internship**,** *Contraves AG*, Zürich, Switzerland
1987-1988 Teaching Assistant**,** *ETH Zürich, Dept. of Materials*, Zürich, Switzerland

Publications: 136 published articles, 4 patents granted, 5 patents pending

Awards:

2012 Visiting Professor, Physics, *University of Vienna*, Austria
2012 Distinguished Professor, *Boise State University*, Boise, ID

Synergistic Activities

- Organization of the 4th International Conference on Ferromagnetic Shape Memory Alloys (ICFSMA'13) in Boise, Idaho, June 3-7, 2013
- Foundational Studies Program Faculty since 2011; developing a university foundations UF100 course for all incoming students; the course is entitled "Invention and Discovery in History and Society"
- Director of the Boise State Center for Materials Characterization since 2006-2011
- Organization and instruction of tutorials and teaching workshops including "Magnetic Shape Memory Alloys" at the MRS Fall Meeting 2009, Boston, MA

- Organization and instruction of the advanced training course 'Materials Science of Thin Films' of the German Society of Materials, Stuttgart, Germany, March 9-11, 1998
- Co-organizer of the International Conference on Ferromagnetic Shape Memory Alloys, ICFSMA'13, June 3-7 2013, Boise ID;
- Co-organizer of MRS Spring Symposium Z "Materials Structures – The Nabarro Legacy", San Francisco, March 25; 2008
- Guest Editor for *Progress in Materials Science*, Vol. 54, Issue 6, Elsevier August 2009 Special Issue "The Nabarro Legacy – Perspectives for advanced materials in the 21st century"
- Co-organizer of the international workshop 'Magnetic Shape Memory Alloys', Ascona, Switzerland, September 11-16. 2005
- Guest lectures at the Royal Institute of Technology, Stockholm, Sweden, February 2008
- Guest lectures at the University of the Basque Country, Bilbao, Spain, July 2010

List of Collaborators (last 4 years)

Dr. M. Barandiaran (Univ. of Basque Country, Bilbao, Spain), Dr. S. Brinckmann (Ruhr University Bochum, Germany), Dr. F. Chen (Harbin Engineering Univeristy, China), Dr. V.A. Chernenko (University of the Basque Country, Bilbao, Spain), Dr. D. C. Dunand (Northwestern University, Evanston, IL), Dr. G. Hampikian (BSU, Boise, ID), Dr. A. H. King (Ames Laboratory, Ames, IA), Dr. W. B. Knowlton (BSU, Boise, ID), Dr. G. Kostorz (ETH Zürich, Switzerland), Dr. V. Michaud (Ecole Polytechnuique Federal, Lausanne, Switzerland), Dr. R. C. Pond (University of Exeter, Exeter, England), Dr. K. Sassaki (BSU, Boise, ID), Dr. C. Sasso (Instituto Nazionale di ricerca Metrologica, Torino, Italy), Dr. R. Schneider (Hahn-Meitner Institute, Berlin, Germany), Dr. K. Ullakko (Savonlinna, Finland), Dr. M. Vreugdenhill (University of Birmingham, England), Dr. T. Waitz (Technical University Vienna, Austria), Dr. Rafal Wroblewski (University of Warsaw, Poland), Dr. Xuexi Zhang (Harbin Institute of Technology, China)

Advisors and Supervisors

Diploma (M.S.): Dr. C. Solenthaler, Dr. M. O. Speidel (ETH Zürich)
Dr. sc. techn. (Ph.D.): Dr. C. Solenthaler, Dr. M. O. Speidel (ETH Zürich)
Post-doctoral sponsor: Dr. W. M. Kriven (University of Illinois, Urbana-Champaing), Dr. E. Arzt (Max-Planck-Institut fur Metallforschung, Stuttgart), Dr. G. Kostorz (ETH Zürich).

Ph.D. Students advised (Institution and year of graduation in parentheses)

A. Hobza (BSU, starting June 2013), J. Huntsinger (BSU, current), Brittany Muntifering (BSU and Ruhr University Bochum, current), Dr. M. Chmielus (BSU, and Technical University Berlin, Germany, 2010), Dr. A. S. Sologubenko (ETH Zürich, Switzerland, 2005), Dr. H. Hesemann (University o Stuttgart, Germany, 2002), Dr. J. Greiser (University o Stuttgart, Germany, 2000).

MS and Diploma Students advised (Institution and year of graduation in parentheses)

T. Lawerence (BSU, current), K. Wilson (BSU, current), D. Kellis (BSU, 2011), C. Witherspoon (BSU, 2011), B. Muntifering (BSU, 2011), M. Hagler (BSU, 2008), D. Carpenter (BSU, ID, 2008), M. Chmielus (BSU, 2007), S. Bianchi (ETH Zürich, Switzerland, 2003), B. E. Burgler (ETH Zürich, Switzerland, 2001).

Total number of graduate students advised: 15
Postdoctoral scholars sponsored 2.

Publications

Patents (P)

P4 C. S. Watson, W. B. Knowlton, and P. Müllner, "Data storage methods and devices", US Patent No. US 2012/0236632 A1, Date of Patent: September 20, 2012.

P3 G. Hampikian and P. Müllner, "Magnetomechanical Transducer, and Apparatus and Methods of Harvesting Energy", US Patent No. US 8,008,816, Date of Patent: August 30, 2011.

P2 P. Müllner, M. Chmielus, D. C. Dunand, Y. Boonyongmaneerat, "Magnetic material with large magnetic-field-induced deformation", US Patent No. US 7,964,290 B2, Date of Patent: June 21, 2011.

P1 P. Müllner and W. B. Knowlton, "Multi-state memory and multi-functional devices comprising magnetoplastic or magnetoelastic materials", US Patent No. US 7,710,766 B2, Date of Patent: May 4, 2010.

Papers in regular journals (J)

J76 S. Glock, X. X. Zhang, N. J. Kucza, P. Müllner, V. Michaud, "Structural, physical and damping properties of melt-spun Ni-Mn-Ga wire-epoxy composites", Composites: Part A 63 (2014) 68-75.

J75 B. Muntifering, R. C. Pond, L. Kovarik, N. D. Browning, P. Müllner, "Intra-variant substructure in Ni-Mn-Ga: Conjugation boundaries", Acta Materialia 71 (2014) 255-263.

J74 I. R. Aseguinolaza, I. Orue, A. V. Svalov, K. Wilson, P. Müllner, J. M. Barandiarán, V. A. Chernenko, "Martensitic transformation in Ni-Mn-Ga/Si(100) thin films", Thin Solid Films 558 (2014) 449-454.

J73 P. Zheng, P. Lindquist, Bin Yuan, P. Müllner, D. Dunand, “Fabricating Ni-Mn-Ga microdubes by diffusion of Mn and Ga into Ni tubes”, Intermetallics 49 (2014) 70-80.

J72 A. Smith, J. Tellinen, P. Müllner, K. Ullakko, “Controlling twin variant configuration in a constrained Ni-Mn-Ga smaple using local magnetic fields”, Scripta Materialia 77 (2014) 68-70.

J71 J. Romberg, C. Hürrich, M. Pötschke, S. Kauffmann-Weiss, U. Gaitzsch, S. Roth, P. Müllner, L. Schultz, “Geometric factors on magnetically driven actuation behavior for polycrystalline Ni-M-Ga and its composites”, Journal of Alloys and Compounds 577S (2013) S344-S347.

J70 M. F. Qian, X. X. Zhang, C. Witherspoon, P. Müllner, “Superelasticity and shape memory effects in polycrystalline Ni-Mn-Ga microwires”, Journal of Alloys and Compounds 577S (2013) S296-S299.

J69 P. Müllner, “Plastic deformation: Shearing mountains atom by atom”, Journal of Alloys and Compounds 577S (2013) S96-S101.

J68 I. R. Aseguinolaza, J. M. Barandiarán, M. Ohtsuka, P. Müllner, O. Y. Salyuk, V. A. Chernenko, “Martensitic transformation and magnetic anisotropy in Ni-Mn-Ga/NaCl(001) thin films probed by ferromagnetic resonance”, Applied Physics Letters 102 (2013) 182401.

J67 C. S. Watson, C. Hollar, K. Anderson, W. B. Knowlton, P. Müllner, “Magnetomechanical Four-State Memory”, Advanced Functional Materials (2013) 201203015.

J66 C. Witherspoon, P. Zheng, M. Chmielus, S. C. Vogel, D. C. Dunand, P. Müllner, “Texture and training of magnetic shape memory foam”, Acta Matertialia 61 (2013) 2113-2120.

J65 I. R. Aseguinolaza, I. Reyes-Salazar, A. V. Svalov, K. Wilson, W. B. Knowlton, P. Müllner, J. M. Barandiarán, E. Villa, V. A. Chernenko, “Transformation volume strain in Ni-Mn-Ga thin films”, Applied Physics Letters 101 (2012) 241912.

J64 U. Gaitzxch, J. Drache, K. McDonald, P. Müllner, P. Lindquist, “Obtaining of Ni-Mn-Ga magnetic shape memory alloy by annealing electrochemically deposited Ga/Mn/Ni layers”, Thin Solid Films 522 (2012) 171-174.

J63 K. Ullakko, L.Wendell, A. Smith, P. Müllner, G. Hampikian “A magnetic shape memory microump: contact-free, and compatible with PCR and human DNA profiling”, Smart Materials and Structures 21 (2012) 115020.

J62 K. Rolfs, M. Chmielus, J. M. Guldbakke, R. C. Wimpory, A. Raatz, W. Petry, P. Müllner, R. Scheider "Key properties of Ni-Mn-Ga based single crystals grown with the SLARE technique", Advanced Engineering Materials 14/8 (2012) 614-635.

J61 D. Kellis, A. Smith, K. Ullakko, and P. Müllner, "Oriented single crystals of Ni-Mn-Ga with very low switching field", Journal of Crystal Growth 359 (2012) 64-68.

J60 R. C. Pond, B. Muntifering, and P. Müllner, "Deformation twinning in Ni_2MnGa", Acta Materialia 60 (2012) 3976-3984.

J59 U. Gaitzsch, J. Romberg, M Pötschke, S. Roth, and P. Müllner, "Stable magnetic-field-induced strain above 1% in polycrystalline Ni-Mn-Ga", Scripta Materialia 65 (2011) 679-682.

J58 C. P. Sasso, P. Zheng, V. Basso, P. Müllner, and D. C. Dunand, "Enhanced field induced martensitic phase transition and magnetocaloric effect in $Ni_{55}Mn_{20}Ga_{25}$ metallic foams", Intermetallics 19 (2011) 952-956.

J57 M. Chmielus, I. Glavatskyy, J.-U. Hoffmann, V. A. Chaernenko, R. Schneider, and P. Müllner, "Influence of constraints and twinning stress on magnetic-field-induced strain of magnetic shape-memory alloys", Scripta Matertialia 64 (2011) 888-891.

J56 M. Chmielus, C. Witherspoon, K. Ullakko, P. Müllner, and R. Schneider, "Effects of surface damage on twinning stress and the stability of twin microstructures of magnetic shape-memory alloys", Acta Matertialia 59 (2011) 2948-2956.

J55 X. X. Zhang, C. Witherspoon, P. Müllner, and D. C. Dunand, "Effect of pore architecture on magnetic-field-induced strain in polycrystalline Ni-Mn-Ga", Acta Matertialia 59 (2011) 2229-2239.

J54 D. C. Dunand, and P. Müllner, "Size effects on magnetic actuation in Ni-Mn-Ga shape-memory alloys", Advanced Matertials 23 (2011) 216-232.

J53 M. Chmielus, C. Witherspoon, R. Wimpory, A. Paulke, A. Hilger, X. X. Zhang, D. C. Dunand, and P. Müllner, "Magnetic-field-induced recovery strain in polycrystalline Ni-Mn-Ga foam", Journal of Applied Physics 108 (2010) 123526.

J52 P. Müllner and A. King, "Deformation of hierarchically twinned martensite", Acta Materialia 58 (2010) 5242-5261.

J51 M. Reinhold, C. Watson, W. B. Knowlton, and P. Müllner, "Transformation twinning of Ni-Mn-Ga characterized with temperature-controlled atomic force microscopy", Journal of Applied Physics 107 (2010) 113501.

J50 M. Chmielus, K. Rolfs, R. Wimpory, W. Reimers, P. Müllner, and R. Schneider, “Effects of surface roughness and training on the twinning stress of Ni-Mn-Ga magnetic shape memory alloys”, Acta Materialia 58 (2010) 3952-3962.

J49 J. Guldbakke, M. Chmielus, K. Rolfs, R. Schneider, P. Müllner, and A. Raatz, “Magnetic, mechanical, and fatigue properties of a $Ni_{45.4}$,$Mn_{29.1}Ga_{21.6}Fe_{3.9}$ single crystal”, Scripta Materialia 62 (2010) 875-878.

J48 K. Rolfs, M. Chmielus, R. C. Wimpory, A. Mecklenburg, P. Müllner, and R. Schneider “Double twinning in Ni-Mn-Ga-Co”, Acta Materialia 58 (2010) 2646-2651.

J47 V. A. Chernenko, M. Chmielus, and P. Müllner, “Large magnetic-field-induced strains in Ni-Mn-Ga non-modulated martensite”, Applied Physics Letters 95 (2009) 103104.

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J45 M. Reinhold, D. Kiener, W. B. Knowlton, G. Dehm, and P. Müllner, “Deformation twinning in Ni-Mn-Ga micropillars with 10M martensite”, Journal of Applied Physics 106 (2009) 053906.

J44 V. A. Chernenko, K. Oikawa, M. Chmielus, S. Besseghini, E. Villa, F. Albertini, L. Righi, A. Paoluzi, P. Müllner, R. Kainuma, and K Ishida, “Properties of Co-alloyed Ni-Fe-Ga ferromagnetic shape memory alloys”, Journal of Materials Engineering and Performance 18/5 (2009) 548-553.

J43 V. Golub, K. M. Reddy, V. A. Chernenko, P. Müllner, A. Punnoose, and M. Ohtuska, “Ferromagnetic resonance properties and anisotropy of Ni-Mn-Ga thin films of different thicknesses deposited on Si substrates”, Journal of Applied Physics 105 (2009) 07A942.

J42 V. A. Chernenko, S. Besseghini, M. Hagler, P. Müllner, M. Ohtuska, and F. Stortiero, “Properties of sputter-deposited Ni-Mn-Ga thin films”, Mater. Science and Engineering A 481-482 (2008) 271-274.

J41 P. Müllner, Z. Clark, L. Kenoyer, W. B. Knowlton, and G. Kostorz, “Nano-mechanics and magnetic structure of orthorhombic Ni-Mn-Ga martensite”, Mater. Science and Engineering A 481-482 (2008) 66-72.

J40 Y. Boonyongmaneerat, M. Chmielus, P. Müllner, D. Dunand, “Increasing magnetoplasticity in polycrystalline Ni-Mn-Ga by reducing internal constraints through porosity”, Physics Review Letters 99 (2007) 247201.

J39 V. A. Chernenko, S. Doyle, M. Kohl, P. Müllner, S. Besseghini, and M. Ohtsuka, “Texture of submicron Ni-Mn-Ga thin films studied by x-ray beam line of synchrotron source”, Z.f. Kristallog. 26 (2007) 229-234.

J38 V. A. Chernenko, S. Besseghini, P. Müllner, G. Kostorz, J. Schreuer, and M. Krupa, “Ferromagnetic shape memory materials: underlying physics and practical importance”, Sensor Letters 5 (2007) 229-233.

J37 V. A. Chernenko, M. Hagler, P. Müllner, V. A. Kniazkyi, V. A. L’vov, M. Ohtuska, S. Besseghini, “Magnetic susceptibility of martensitic Ni-Mn-Ga film”, Journal of Applied Physics 101 (2007) 053909.

J36 P. Müllner, “Between microscopic and mesoscopic descriptions of twin-twin interaction”, Int. Journal of Mater. Res. (formerly Z. f. Metallkunde), 97/3 (2006) 205-216.

J35 V. Chernenko, M. Kohl, S. Doyle, P. Müllner, and M. Ohtsuka, “Texture dependence of the martensitic transformation in Ni-Mn-Ga films deposited on alumina”, Scripta Materialia 54 (2006) 1287-1291.

J34 A. Al-Ghaferi, P. Müllner, H. Heinrich, G. Kostorz, and J. M. K. Wiezorek, “Elastic constants of equiatomic $L1_0$-ordered FePd single crystals”, Acta Materialia 54 (2006) 881-889.

J33 G. Kostorz and P. Müllner, “Magnetoplasticity”, Z. f. Metallkunde 96 (2005) 703-709.

J32 A. Sologubenko, P. Müllner, H. Heinrich, and G. Kostorz, “Formation of twinned tetragonal ferromagnetic $L1_0$-MnAl-C alloys”, Arch. Metall. Mater. 49/4 (2004) 863-867.

J31 A. S. Sologubenko, P. Müllner, H. Heinrich, and G. Kostorz, “On the plate-like □-phase formation in MnAl-C alloys“, Z. f. Metallkunde 95 (2004) 486-491.

J30 P. Müllner, V. A. Chernenko, and G. Kostorz, “Large magnetic-field-induced deformation and magneto-mechanical fatigue of ferromagnetic Ni-Mn-Ga martensites”, Mater. Sci. Eng. A 387-389 (2004), 965-968.

J29 V. A. Chernenko, V. A. L’vov, P. Müllner, G. Kostorz, and T. Takagi, “Magnetic-field-induced superelasticity of ferromagnetic thermoelastic martensites: Experiment and modeling”, Phys. Rev. B 69 (2004) 134410.

J28 P. Müllner, V. A. Chernenko, and G. Kostorz, “Large cyclic magnetic-field-induced deformation in orthorhombic (14M) Ni-Mn-Ga martensite”, J. Appl. Phys. 95/3 (2004) 1531-1536.

J27 P. Müllner, V. A. Chernenko, and G. Kostorz, “A microscopic approach to the magnetic-field-induced deformation of martensite”, J. Magn. Magn. Mater. 267/3 (2003) 325-334.

J26 P. Müllner, V. A. Chernenko, and G. Kostorz, “Stress-induced twin rearrangement resulting in change of magnetization in a Ni-Mn-Ga ferromagnetic martensite”, Scripta Mater. 49/2 (2003) 129-133.

J25 H. Th. Hesemann, P. Müllner, O. Kraft, D. Nowak, S. P. Baker, K. Finkelstein, and E. Arzt, “Texture dependence of the martensitic transformation in cobalt thin films”, Scripta Mater. 48/8 (2003) 1129-1133.

J24 P. Müllner, V. A. Chernenko, M. Wollgarten, and G. Kostorz, “Large cyclic deformation of Ni-Mn-Ga induced by magnetic fields”, J. Appl. Phys. 92/11 (2002) 6708-6713.

J23 P. Müllner, B. E. Bürgler, H. Heinrich, A. S. Sologubenko, and G. Kostorz, “Observation of the shear mode of the □→□ transformation in a Mn-Al-C single crystal”, Phil. Mag. Lett. 82 (2002) 71-79.

J22 J. Greiser, P. Müllner, and E. Arzt, “Abnormal growth of ‘giant’ grains in silver thin films”, Acta Mater. 49/6 (2001) 1041-1050.

J21 H. Th. Hesemann, P. Müllner, and E. Arzt, “On stress and texture development during martensitic transformation in cobalt thin films”, Scripta Mater. 44/1 (2001) 25-30.

J20 P. Müllner and A. E. Romanov, “Internal twinning in deformation twinning”, Acta Mater. 48/9 (2000) 2323-2337.

J19 J. Greiser, D. Müller, P. Müllner, C. V. Thompson, and E. Arzt, “Growth of giant grains in silver thin films”, Scripta Mater. 41/7 (1999) 709-714.

J18 P. J. Ferreira and P. Müllner, “On a thermodynamic model for the stacking-fault energy”, Acta Mater. 46/13 (1998) 4479-4484.

J17 P. Müllner and K. Ullakko, “The force of a magnetic/electric field on a twinning dislocation”, phys. stat. sol. (b) 208 (1998) R1-R2.

J16 P. Müllner, “On the ductile to brittle transition of austenitic steel”, Mater. Sci. Eng. A 234-236 (1997) 94-97.

J15 P. Müllner and P. Pirouz, “A disclination model for twin intersection and the formation of hexagonal Silicon and Germanium”, Mater. Sci. Eng. A 233 (1997) 139-144.

J14 P. Müllner and W. M. Kriven, “On the role of deformation twinning in domain reorganization and grain reorientation in ferroelastic crystals”, J. Mat. Res. 12/7 (1997) 1771-1776.

J13 P. Müllner and C. Solenthaler, “On the effect of deformation twinning on defect densities”, Mater. Sci. Eng. A 230/1-2 (1997) 107-115.

J12 P. Müllner and W.-M. Kuschke, “On the formation of disclinations in fine-grained materials and thin films due to grain boundary relaxation”, Scripta Mater. 36/12 (1997) 1451-1455.

J11 P. Müllner, H. Gao, and C. Ozkan, “A twinned wedge in a Si-Ge epitaxial thin film: twofold [illegible] twinning”, Phil. Mag. A 75/4 (1997) 925

J10 P. Müllner and P. J. Ferreira, “On the energy of terminated stacking faults”, Phil. Mag. Lett. 73/6 (1996) 289-297.

J9 S. V. Kamat, J. P. Hirth, and P. Müllner, “The effect of stress on the shape of a blocked deformation twin”, Phil. Mag. A 73/3 (1996) 669-680.

J8 P. Müllner, “In-plane edge Somigliana dislocation dipoles and quadrupoles”, Scripta metall. mater. 33/7 (1995), 1181-1186. Ibid. 35/7 (1996) 903.

J7 N. Paulus, P. J. Uggowitzer, P. Müllner and M. O. Speidel, “Cold and warm work of austenitic nitrogen steels”, La Metall. Ital. 86/12 (1994) 603-608.

J6 P. Müllner and A. E. Romanov, “Between dislocation and disclination models for twins”, Scripta Metall. Mater. 31/12 (1994) 1657-1662.

J5 P. Müllner, C. Solenthaler, P. J. Uggwitzer and M. O. Speidel, “Brittle fracture in austenitic steel”, Acta Metall. Mater. 42/7 (1994) 2211-2217.

J4 P. Müllner, C. Solenthaler and M. O. Speidel, “Second order twinning in austenitic steel”, Acta Metall. Mater. 42/5 (1994) 1727-1732.

J3 P. Müllner and C. Solenthaler, “The shape of a blocked deformation twin”, Phil. Mag. Lett. 69/4 (1994) 171-175.

J2 P. Müllner and C. Solenthaler, “A proper model of a deformation twin for twin-intersection problems”, Phil. Mag. Lett. 69/3 (1994) 111-113.

J1 P. Müllner, C. Solenthaler, P. J. Uggowitzer and M. O. Speidel, “On the effect of nitrogen on the dislocation structure of austenitic stainless steel”, Mat. Sci. Eng. A 164 (1993) 164-169.

Edited works (E)

E1 S. B. Sant, P. Müllner, and G. R. Purdy (editors), "The Nabarro Legacy – Perspectives for Advanced Materials in the 21st Century". A collection of invited lectures at the MRS Spring Meeting 2008 in Progress in Materials Science, specially issue 54/6, August 2009.

Contributions to books and edited works (B)

B3 M. Chmielus and P. Müllner, "Effects of surface pinning, locking, and adaption of twins on the performance of magnetic shape-memory alloys", in 'Advances in Magnetic Shape Memory Materials', Materials Science Forum 684 (2011) 175-199.

B2 P. Müllner and G. Kostorz, "Microstructure of magnetic shape-memory alloys: between magnetoelasticity and magnetoplasticity", in 'Advances in Shape Memory Alloys', Ed. V. A. Chernenko, Trans Tech Publications, Materials Science Forum 583 (2008) 43-65.

B1 G. Dehm and P. Müllner, "Dislocations in thin films: Observations", in 'The Encyclopedia of Materials: Science and Technology', Vol. 4, Eds. K. H. J. Buschow, R. W. Cahn, M. C. Flemings, B. Ilschner, E. J. Kramer, S. Mahajan, Elsevier, Oxford 2001, 2329-2331.

Invited conference contributions (I)

I26 *P. Müllner*, "Localized magnetic-field-induced deformation for micro-machines", XXII International Materials Research Congress, Cancú, Mexico, August 11-16, 2013, Symp. 7A "Magnetic shape memory alloys: from fundamentals to applications", without proceedings.

I25 *P. Müllner*, C. Watson, C. Hollar, K. Anderson, W. B. Knowlton, "Corrugation-Induced Patterning of Ni-Mn-Ga (100) Surfaces", MRS Spring Meeting 2013, San Francisco, CA, April 2-4, Symp. BBB "Size-Dependent and Coupled Properties of Materials", without proceedings.

I24 *P. Müllner*, B. Muntifering, R. C. Pond, L. Kovarik, N. Browning, "Mechanics of Twinning and Twin Structures in Ni-Mn-Ga", CIMTEC'12 Conference, Symposium B: State-of-the-Art Research and Application of SMAs Technologies, June 10-14, 2012, Montecatini Terme, Italy, without proceedings.

I23 *P. Müllner*, "Mechanics of magnetic shape memory alloys across the length scales", TMS Spring Conference, Symposium Neutron and X-Ray Studies of Advanced Materials V: Centennial, March 11-15, 2012, Orlando, FL, without proceedings.

I22 *P. Müllner*, "Deformation of materials with complex microstructures: from shifting atoms to moving mountains", International Conference on Martensitic Transformations 'ICOMAT'11', Osaka, Japan, September 4-9, 2011, manuscript submitted to Journal of Alloys and Compounds.

I21 M. Chmielus, K. Ullakko, R. Schneider , *P. Müllner*, "The Role of Constrained Surfaces on Magnetic-Field-Induced Deformation", International Conference on Ferromagnetic Shape Memory Alloys 'ICFSMA'11', Dresden, Germany, July 18-22, 2011, extended abstract book, pp. 209-210.

I20 *P. Müllner*, M. Chmielus, C. Witherspoon, R. Schneider, K. Ullakko "Effects of surface modifications on twinning stress and the stability of twin microstructures of magnetic shape-memory alloys", TMS Spring Meeting, Focus Symposium 'Physical and Mechanical Metallurgy of Shape Memory Alloys', San Diego, CA, February 28-March 3, 2011, without proceedings.

I19 *P. Müllner*, P. Lindquist, K. Wilson, A. Rothenbühler, G. Lindquist, D. Carpenter, K. Ullakko "Inverse magnetoplasticity and power generation using Ni-Mn-Ga", European Materials Research Society symposium 'Shape Memory Materials for Smart Systems', E-MRS-Spring Meeting, Strasbourg, France June 7-11, 2010, without proceedings.

I18 *P. Müllner*, A. H. King "Deformation of hierarchically twinned martensite", Materials Research Society symposium 'Magnetic Shape Memory Alloys', MRS-Fall meeting, Boston, MA November 29-December 2, 2009, without proceedings.

I17 *P. Müllner*, X.X. Zhang, Y. Boonyongmaneerat, C. Witherspoon, M. Chmielus, D.C. Dunand "Recent developments in Ni-Mn-Ga foam research", International Conference on Ferromagnetic Shape Memory Alloys 'ICFSMA'09', Bilbao, Spain, July 1-3, 2009, Materials Science Forum 635 (2010) 119-124.

I16 *P. Müllner*, "Twin microstructure, line defects, and deformation mechanisms of magnetic shape-memory alloys", Proc. of the International Conference on Martensitic Transformations 'ICOMAT'08', Santa Fe, NM, June 29-July5, 2008, (2009) 79-88.

I15 *P. Müllner*, "Twinning in magnetic shape-memory alloys", 'Behavior of Defects in Materials', DoE BES Contractors Meeting, Airlie Conference Center, Warrenton, VA, April 13-16, 2008, without proceedings.

I14 *P. Müllner*, A. S. Geleynse, D. R. Carpenter, M. S. Hagler, and M. Chmielus, "Modeling magnetoplasticity and magnetoelasticity with disconnections and disclinations", Materials Research Society symposium 'Magnetic Shape Memory Alloys', MRS-Fall meeting, Boston, MA November 26-December 30, 2007, MRS Symp. Proc. E 1050 (2008) BB02-01.

I13 *P. Müllner*, "Training, twin-microstructure, and performance of magnetic shape-memory alloy single crystals", Focus meeting SPP 1239, Dresden, Germany Februry 28-March 1, 2007, without proceedings.

I12 *P. Müllner*, M. Chmielus, L. Kenoyer, Z. Clark, M. Reinhold, W. B. Knowlton, and G. Kostorz, "Magnetoplasticity and nano-magneto-mechanics of magnetic shape-memory

alloys", Materials Research Society symposium II 'Advanced Intermetallic-Based Alloys', MRS-Fall meeting, Boston, MA November 26-December 1 2006, without proceedings.

I11 *G. Kostorz*, P. Müllner, "Ferromagnetic shape memory alloys", TMS 'XX Conference on Applied Crystallography', Wisla, Poland, September 11-14, 2006, without proceedings.

I10 *P. Müllner*, Z. Clark, L. Kenoyer, W. B. Knowlton, and G. Kostorz, "Nano-mechanics and magnetoplasticity of magnetic shape-memory alloys", 'European Symposium on Martensitic Transformations and Shape-Memory Alloys' (ESOMAT 2006), Bochum, Germany, September 10-15 2006, Mater. Science and Engineering A 481-482 (2008) 66-72.

I9 *P. Müllner*, "Micro- and Nano-magneto mechanics of magnetic shape-memory alloys", 'Physics and Materials', Farewell Symposium for Professor Gernot Kostorz, Zurich, Switzerland, May 31-June 1, 2006, without proceedings.

I8 G. Kostorz, *P. Müllner*, "Martensitic transformations and magnetic shape memory in Heusler alloys", TMS Symposium 'Phase Transformations in Magnetic Materials', San Antonio, TX, USA, March 12-16, 2006, without proceedings.

I7 *P. Müllner*, "Magnetoplasticity", Int. Workshop on 'Magnetic Shape Memory Alloys', Ascona, Switzerland, September 11-16 2005, without proceedings.

I6 *P. Müllner*, D. Mukherji, M. Aguirre, R. Erni, G. Kostorz, "Micromechanics of magnetic-field-induced twin boundary motion", Proc. International Conference 'Solid-Solid Phase Transformations in Inorganic Materials', Phoenix, AZ, USA, May 28-June 3 2005, Warrendale, MA (2005), pp. 171-185.

I5 *P. Müllner*, "Magnetoplasticity: Key to novel sensors and actuators", Symposium 'Future trends in metallurgy and materials development', Düsseldorf, Germany, March 31-April 1 2003, without proceedings.

I4 *P. Müllner*, "Magnetoplasticity: Key to novel sensors and actuators", 6th Budapest-Zürich Seminar in Materials Science, Flüelen, Switzerland, May 26-29 2002, without proceedings.

I3 *P. Müllner*, A. S. Sologubenko, and H. Heinrich, "The □+□ transformation in Mn-Al-C single crystals", Int. Conference on 'Stability of Materials', Ascona, Switzerland, March 4-10 2001, without proceedings.

I2 *P. Müllner*, "Disclination models for deformation twinning", Int. workshop 'Local lattice rotations and disclinations in microstructures of distorted crystals', Rauschenbach, Germany, April 10-14 2000; Eds. P. Klimanek, A. E. Romanov, B. M. Seefeld, Solid State Phenomena 87 (2002), 227-238.

I1 *P. Müllner*, “Somigliana dislocations and disclinations in epitaxial thin films”, ‘Semiconductor thin films and multilayers’, focus symposium at the APS-Spring-Meeting 1997, Kansas City, MO, March 17-21 1997, without proceedings.

Conference contributions (C)

C101 *T. Waitz*, C. Mangler, A. E. Kompatscher, N. Kucza, P. Müllner, T. Antretter, “Adaptive martensite in ultrafine grained $Ni_{54}Mn_{25}GA_{21}$”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 164-165.

C100 *B. Muntifering*, L. Kovarik, N. D. Browning, R. C. Pond, P. Müllner, “Conjugation Boundary in Non-Modulated Ni-Mn-Ga Martensite”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 130-131.

C99 *P. Lindquist*, G. Lindquist, A. Rothenbühler, P. Müllner, “Dynamic measurement of the mechanical behavior of ferromagnetic shape memory alloys for power generation”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 122-123.

C98 *T. Lawrence*, S. R. Barker, A. J. Morrison, B. Blessie, A. R. Smith, K. Ullakko, P. G. Lindquist, P. Müllner, “Method for determining the effect of surface treatments on fatigue life in Ni-Mn-Ga alloys”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 120-121.

C97 *N. Kucza*, B. Muntifering, P. Müllner, “Characterization of Ni-Mn-Ga single crystals grown using the Bridgman-Stockbarger technique”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 118-119.

C96 *J. Huntsinger*, K. Wilson, A. Thompson, W. B. Knowlton, P. Müllner, “Fabrication and characterization of Ni-Mn-Ga microdots via electron-beam lethography”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 108-109.

C95 *C. Hollar*, C. S. Watson, W. B. Knowlton, P. Müllner, “Nanomechanical Properties of Ni-Mn-Ga”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 106-107.

C94 *A. R. Smith*, P. Müllner, K. Ullakko, “Controlling twin variant configuration in Ni-Mn-Ga using local magnetic fields”, International Conference on Ferromagnetic Shape

Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 96-97.

C93 *I. R. Aseguinolaza*, B. Muntifering, J. Brotherton, W. B. Knowlton, P. Müllner, J. M. Barandiaran, V. A. Chernenko, “Structural, magnetic and transformation bvehavior of Ni-Mn-Ga/MgO (100) thin films”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 90-91.

C92 *S. Glock*, X. X. Zhang, N. Kucza, P. Müllner, V. Michaud, “Melt-spun NiMnGa Wire/Epoxy Composite Materials”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 82-83.

C91 *X. X. Zhang*, M. F. Qian, C. Witherspoon, P. Müllner, L. Geng, “Shape Memory Effect in Polycrystalline NiMnGa Microwires”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 80-81.

C90 *P. Zheng*, N. Kucza, P. Müllner, D. C. Dunand, “Enhanced Manetic-Field-Induced Strain of NI-Mn-Ga Foam by Directional Solidification”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 78-79.

C89 *B. Yuan*, P. Lindquist, P. Zheng, P. Müllner, D. C. Dunand, “Fabricating Ni-Mn-Ga Microtubes by Diffusion of Mn and Ga into Ni Tubes”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 74-75.

C88 *B. Reinholz*, S. Brinckmann, B. Muntifering, W. B. Knowlton, P. Müllner, A. Hartmaier, “Application of Disclination Dynamics: Twin Boundary Motion in Magnetic Shape-Memory Alloys”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 32-33.

C87 *S. Brinckmann*, B. Reinholz, P. Müllner, “Discrete Disclinatino Dynamics and Discrete Dislocation Dynamics”, International Conference on Ferromagnetic Shape Memory Alloys ‘ICFSMA’13’, Boise, Idaho, June 3-7, 2013, extended abstract book, pp. 30-31.

C86 *T. Waitz (invited)*, C. Mangler, P. Schindler, E. Schafler, P. Müllner, V. Srivastava, R. D. James, “Ultrafine Grained Shape Memory Alloys: Martensitic Phase Ttransformations, Reversibility, Hysteresis”, MRS Spring Meeting 2013, San Francisco, CA, April 2-4, Symp. CCC “Novel Functionality by Reversible Phase Transformation”, without proceedings.

C85 K. Wilson, *P. Lindquist*, J. Hutnsinger, B. Muntifering, W. B. Knowlton, P. Müllner, “Magnetic and Structural Properties of Ni-Mn-Ga Films Grown via Physical Vapor Co-

deposition", MRS Spring Meeting 2013, San Francisco, CA, April 2-4, Symp. BBB "Size-Dependent and Coupled Properties of Materials", without proceedings.

C84 T. Lawrence, A. Smith, P. Lindquist, K. Ullakko, *P. Müllner*, "Localized Morphing and Fracture of Magnetic Shape Memory Alloys", 'Mechanical Behavior and Radiation Effects', DoE BES PI Meeting, Bolger Center, Potomac, MD, March 25-27, 2013, without proceedings.

C83 *B. Muntifering*, L. Kovarik, R. C. Pond, N. D. Browning, P. Müllner, "Intra-Variant Boundary in Non-Modulated Ni-Mn-Ga", TMS Spring Conference, Symposium Physical and Mechanical Metallurgy of Shape Memory Alloys, March 4-8, 2013, San Antonio, TX, without proceedings.

C82 *P. Zheng*, B. Yuan, D. C. Dunand, P. Lindquist, P. Müllner, "Fabricating Tubes of Ni-Mn-Ga Magnetic Shape Memory Alloys by Interdiffusion of Mn and Ga into Ni Tubes", TMS Spring Conference, Symposium Physical and Mechanical Metallurgy of Shape Memory Alloys, March 4-8, 2013, San Antonio, TX, without proceedings.

C81 *R. C. Pond*, B. Muntifering, P. Müllner, "Deformation Twinning in Ni2MnGa", CIMTEC'12 Conference, Symposium B: State-of-the-Art Research and Application of SMAs Technologies, June 10-14, 2012, Montecatini Terme, Italy, without proceedings.

C80 *T. Waitz*, C. Mangler, M. Peterlechner, G. Steiner, A. Kompatscher, T. Antretter, F. D. Fischer, P. Müllner, "Nanostructured shape memory alloys: processing, martensitic phase transformations, properties", CIMTEC'12 Conference, Symposium B: State-of-the-Art Research and Application of SMAs Technologies, June 10-14, 2012, Montecatini Terme, Italy, without proceedings.

C79 *T. Waitz*, C. Mangler, G. Steiner, A. Kompatscher, M. Peterlechner, W. Pranger, T. Antretter, F. D. Fischer, P. Müllner, "Ultrafine-Grained Shape Memory Alloys", TMS Spring Conference, Symposium, March 11-15, 2012, Orlando, FL, without proceedings.

C78 *A. Rothenbühler*, E. Barney Smith, P. Müllner, "Application of image processing to track twin boundary motion in magnetic shape memory alloys", Proc. SPIE Electronic Imaging- Image Processing: Machine Vision Applications V, Burlingame, CA, Vol. 8300. January 25, 2012. Paper 8300-0A.

C77 *M. F. Qian*, X. X. Zhang, C. Witherspoon, I. F. Sun, P. Müllner, "Superelasticity and shape memory effects in polycrystalline Ni-Mn-Ga microwires", International Conference on Martensitic Transformations 'ICOMAT'11', Osaka, Japan, September 4-9, 2011, Journal of Alloys and Compounds (in press).

C76 *T. Waitz*, C. Mangler, G. Steiner, M. Peterlechner, W. Pranger, T. Antretter, F. D. Fischer, P. Müllner, "Nanocrystalline shape memory alloys processed by severe plastic deformation", International Conference on Martensitic Transformations 'ICOMAT'11', Osaka, Japan, September 4-9, 2011, submitted to Journal of Alloys and Compounds.

C75 C. Mangler, *A. E. Kompatscher*, P. Müllner, T. Waitz, "TEM investigation of ferromagnetic shape memory alloys subjected to severe plastic deformation", Microscopy MC 2011 Conference, Kiel, Germany, August 28 - September 2, 2011, conference proceedings article number M2-P538.

C74 *N. Kucza*, B. Siewert, M. Flores Ramos, A. Rothenbühler, P. Müllner, "Grain size distribution and grain growth in polycrystalline Ni-Mn-Ga", International Conference on Ferromagnetic Shape Memory Alloys 'ICFSMA'11', Dresden, Germany, July 18-22, 2011, extended abstract book, pp. 161-162.

C73 *B. Muntifering*, R. C. Pond, P. Müllner, "Twinning Mechanisms in Non-Modulated Ni-Mn-Ga", International Conference on Ferromagnetic Shape Memory Alloys 'ICFSMA'11', Dresden, Germany, July 18-22, 2011, extended abstract book, pp. 159-160.

C72 *C. Watson*, W. B. Knowlton, P. Müllner, "Localized stress-induced twinning in Ni-Mn-Ga single crystals", International Conference on Ferromagnetic Shape Memory Alloys 'ICFSMA'11', Dresden, Germany, July 18-22, 2011, extended abstract book, pp. 197-198.

C71 *U. Gaitzsch*, J. Drache, K. McDonald, P. Müllner, P. Lindquist "Electrochemical Deposition of Ni_2MnGa Martensitic Alloy", International Conference on Ferromagnetic Shape Memory Alloys 'ICFSMA'11', Dresden, Germany, July 18-22, 2011, extended abstract book, pp. 143-144.

C70 C. Mangler, *T. Waitz*, P. Müllner, "Severe plastic deformation of high temperature Ni-Mn-Ga shape memory alloys studied by TEM and DSC", International Conference on Ferromagnetic Shape Memory Alloys 'ICFSMA'11', Dresden, Germany, July 18-22, 2011, extended abstract book, pp. 125-126.

C69 X. X. Zhang, C. Witherspoon, P. Müllner, *D. C. Dunand*, "Magnetic-field-induced strain in porous, polycrystalline Ni-Mn-Ga", International Conference on Ferromagnetic Shape Memory Alloys 'ICFSMA'11', Dresden, Germany, July 18-22, 2011, extended abstract book, pp. 121-122.

C68 *T. Waitz*, W. Pranger, C. Mangler, M. Peterlechner, G. Steiner, T. Antretten, F. D. Fischer, P. Müllner "Nanocrysatlline Shape Memory Alloys", TMS Spring Meeting, Focus Symposium 'Physical and Mechanical Metallurgy of Shape Memory Alloys', San Diego, CA, February 28-March 3, 2011, without proceedings, T. Waitz gave an invited talk.

C67 *P. Zheng*, B. Ye, C. Witherspoon, P. Müllner, D. C. Dunand "Powder metallurgy processing of replicated Ni-Mn-Ga foams", TMS Spring Meeting, Focus Symposium 'Physical and Mechanical Metallurgy of Shape Memory Alloys', San Diego, CA, February 28-March 3, 2011, without proceedings.

C66 *D. Kellis*, K. Ullakko, P. Müllner "Growth of oriented nickel manganese gallium single crystals via the Bridman method", TMS Spring Meeting, Focus Symposium 'Physical and Mechanical Metallurgy of Shape Memory Alloys', San Diego, CA, February 28-March 3, 2011, without proceedings.

C65 *T. Waitz*, C. Mangler, G. Steiner, M. Peterlechner, T. Antretter, F. D. Fischer, W. Pranger, P. Müllner, "Multifunctional shape memory alloys processed by SPD", Proceedings of the International Symposium on Giant Straining Process for Advanced Materials (GESAM 2010), Fukuoka, Japan, November 19-22, 2010, pp.

C64 M. Chmielus, C. Witherspoon, R. Schneider, *P. Müllner*, "Surface damage and twinning stress of Ni-Mn-Ga single crystals", 'Mechanical Behavior and Radiation Effects', DoE BES Contractors' Meeting, Rockville Hilton, Rockville, MD, September 28-October 1, 2010, without proceedings.

C63 *C. Mangler*, M. Kerber, P. Müllner, T. Waitz "Effects of severe plastic deformation on the high temperature magnetic shape memory alloy Ni-Mn-Ga", Joint European Magnetic Symposia JEMS 2010, Kraków, Poland, August 23-28, 2010, without proceedings.

C62 *B. Muntifering*, R. C. Pond, G. Kostorz, P. Müllner, "Electron diffraction of 2M and 14M Ni-Mn-Ga and the analysis of twinning disconnections", European Materials Research Society symposium 'Shape Memory Materials for Smart Systems', E-MRS-Spring Meeting, Strasbourg, France June 7-11, 2010, without proceedings.

C61 *C. Witherspoon*, P. Zheng, M. Chmielus, P. Müllner, D. C. Dunand, "Porosity and magneto-mechanical properties of magnetic shape memory foam", European Materials Research Society symposium 'Shape Memory Materials for Smart Systems', E-MRS-Spring Meeting, Strasbourg, France June 7-11, 2010, without proceedings.

C60 *P. Müllner*, A. H. King "Disclinations and deformation of hierarchically twinned martensite", in 'The Vasek Vitek Honorary Symposium on Crystal Defects', Computational Materials Science and Applications at TMS Spring Meeting, Seattle, WA, February 14-18, 2010, without proceedings.

C59 *M. Chmielus*, K. Rolfs, C. Witherspoon, N. Kucza, W. Raimers, P. Müllner, R. Schneider, "Effecrts of surface preparation and training on twinning stress of Ni-Mn-Ga single crystals", Materials Research Society symposium 'Magnetic Shape Memory Alloys', MRS-Fall meeting, Boston, MA November 29-December 2, 2009, without proceedings.

C58 *D. Kellis*, M. Hagler, V. A. Chernenko, M. Ohtsuka, W. B. Knowlton, P. Müllner, "Effect of film thickness on texture and magnetic anisotropy of Ni-Mn-Ga films on (100) silicon", International Conference on Ferromagnetic Shape Memory Alloys 'ICFSMA'09', Bilbao, Spain, July 1-3, 2009, without proceedings.

C57 *M. Chmielus*, K. Rolfs, C. Witherspoon, W. Raimers, P. Müllner, R. Schneider, "Influence of surface condition and training on the twinning stress of Ni-Mn-Ga magnetic shape-memory alloys", Conference of the German Physical Society, München, Germany, March 2009, without proceedings.

C56 *K. Rolfs*, M. Chmielus, R. C. Wimpory, P. Müllner, W. Petry, R. Schneider, "Influence of alloying Ni-Mn-Ga with cobalt on structural, mechanical and magnetic properties", Conference of the German Physical Society, München, Germany, March 2009, without proceedings.

C55 *P. Müllner*, M. Reinhold, W. B. Knowlton, D. Kiener, G. Dehm, "Magneto-mechanics of Ni-MN-Ga magnetic shape-memory micropillars", MRS Spring Meeting 2009, San Francisco, CA, April 13-17, II "Probing mechanics on nanoscale dimensions", without proceedings.

C54 *P. Müllner*, C. Witherspoon, M. Chmielus, X. Zhang, P. Zheng, D. C. Dunand, "Magneto-mechanics of Ni-MN-Ga magnetic shape-memory micropillars", MRS Spring Meeting 2009, San Francisco, April 13-17, LL "Architectured multifunctional materials", without proceedings.

C53 V. Golub, *K. M. Reddy*, V. A. Chernenko, P. Müllner, A. Punnoose, and M. Ohtuska, "Ferromagnetic resonance properties and anisotropy of Ni-Mn-Ga thin films of different thicknesses deposited on Si substrates", 53rd Conference on Magnetism and Magnetic Materials, Austin, TX, November 10-14, 2008, Journal of Applied Physics 105 (2009) 07A942.

C52 *V. A. Chernenko*, K. Oikawa, M. Chmielus, S. Besseghini, E. Villa, F. Albertini, L. Righi, A. Paoluzi, P. Müllner, R. Kainuma, K. Ishida, "Properties of Co-alloyed Ni-Fe-Ga ferromagnetic shape memory alloys", International Conference on Shape Memory and Superelastic Technologies (SMST 2008), Stresa, Italy, September 21-25, 2008, Journal of Materials Engineering and Performance 18/5 (2009) 548-553.

C51 *M. Reinhold*, W. B. Knowlton, P. Müllner, "Characterizating twin structure and magnetic domain structure of Ni-Mn-Ga through atomic force microscopy", Proc. of the International Conference on Martensitic Transformations 'ICOMAT'08', Santa Fe, NM, June 29-July5, 2008, (2009) 299-304.

C50 *M. Hagler*, V. A. Chernenko, M. Ohtsuka, S. Bessighini, P. Müllner, "Martensitic transformation in Ni-Mn-Ga thin films deposited on alumina", Proc. of the International Conference on Martensitic Transformations 'ICOMAT'08', Santa Fe, NM, June 29-July5, 2008, (2009) 453-457.

C49 *M. Chmielus*, V. A. Chernenko, A. Hilger, G. Kostorz, P. Müllner, R. Schneider, "Magneto-mechanical properties and fracture of mechanically constrained Ni-Mn-Ga single crystals after extended magnetic cycling", Proc. of the International Conference on

Martensitic Transformations 'ICOMAT'08', Santa Fe, NM, June 29-July5, 2008, (2009) 683-688.

C48 *D. Carpenter*, M. Chmielus, A. Rothenbühler, R. Schneider, P. Müllner, "Application of ferromagnetic shape-memory alloys in power generation devices", Proc. of the International Conference on Martensitic Transformations 'ICOMAT'08', Santa Fe, NM, June 29-July5, 2008, (2009) 365-369.

C47 M. Chmielus, D. Carpenter, A. Geleynse, M. Hagler, R. Scheider, P. Müllner, "Numerical simulation of twin-twin interaction in magnetic shape-memory alloys", MRS Spring Meeting 2008, San Francisco, March 24-28, Symposium Z "Structure of Materials – The Nabarro Legacy", MRS E Proc. 1090 (2008) Z05-26.

C46 A. Bellou, S. Candelaria, M. Hagler, P. Müllner, D. F. Bahr, "Fracture and deformation in multi-layer metallic films", MRS Spring Meeting, San Francisco, CA, March 24-28, 2008, without proceedings.

C45 V. A. Chernenko, R. Lopez-Anton, S. Besseghini, J. M. Barandiaran, M. Ohtuska, A. Gambardella, P. Müllner, "Magnetization and domain patterns in martensitic NiMnGa films on Si(100) wafer", International Conference on Ferromagnetic Shape Memory Alloys, Kolkata, India, November 14-16, 2007, Advanced Materials Research 52 (2008) 35-43.

C44 S. Doyle, V. A. Chernenko, S. Besseghini, A. Gambardella, M. Kohl, P. Müllner, and M. Ohtsuka, "Residual Stress in Ni-Mn-Ga thin films deposited on different substrates", E-MRS Fall Meeting 2007, Warsaw, Poland, September 17-21, Europ. Phys. J. S. T. 158 (2008) 179-185.

C43 S. Besseghini, A. Gambardella, V. A. Chernenko, M. Hagler, C. Pohl, P. Müllner, M. Ohtuska, and S. Doyle, "Transformation behavior of Ni-Mn-Ga/Si(100) thin film composites with different film thicknesses", E-MRS Fall Meeting 2007, Warsaw, Poland, September 17-21, Europ. Phys. J. S. T. 158 (2008) 179-185.

C42 *M. Chmielus*, V.A. Chernenko, W.B. Knowlton, G. Kostorz, P. Müllner, "Training, constraints, and high-cycle magneto-mechanical properties of Ni-Mn-Ga magnetic shape-memory alloys", E-MRS Fall Meeting 2007, Warsaw, Poland, September 17-21, Europ. Phys. J. S. T. 158 (2008) 79-85.

C41 *M. Hagler*, V.A. Chernenko, M. Ohtsuka, S. Besseghini, P. Müllner, "Magnetic anisotropy, stress, and martensitic transformation in Ni-Mn-Ga thin films on Si(001) wafer", MRS symposium 'Nanoscale magnetics and device applications', MRS-Spring-Meeting 2007, San Francisco, April 9-13, 2007, Mater. Res. Soc. Symp. Proc. Vol 998 (electronic), 0998-J06-09.

C40 *V. A. Chernenko*, S. Doyle, M. Kohl, P. Müllner, S. Besseghini, and M. Ohtsuka, "Texture of submicron Ni-Mn-Ga thin films studied by x-ray beam line of synchrotron

source", 'European Powder Diffraction Conference' (EPDIC 2006), Geneva, Switzerland, September 1-4, 2006, Z.f.Kristallography 26 (2007) 229-234.

C39 *V. A. Chernenko*, S. Besseghini, M. Hagler, P. Müllner, M. Ohtsuka, and F. Stortiero, "Properties of sputter-deposited Ni-Mn-Ga thin films", 'European Symposium on Martensitic Transformations and Shape-Memory Alloys' (ESOMAT 2006), Bochum, Germany, September 10-15 2006, Mater. Science and Engineering A 481-482 (2008) 271-274.

C38 *V. A. Chernenko*, S. Besseghini, P. Müllner, G. Kostorz, J. Schreuer, and M. Krupa, "Ferromagnetic shape memory materials: underlying physics and practical importance", '6th European Conference on Magnetic Sensors and Actuators' (EMSA'06), Bilbao, Spain, July 3-5 2006, Sensor Letters 5 (2007) 229-233.

C37 M. Hagler, Z. Clark, L. Kenoyer, M. Chmielus, V. Chernenko, M. Ohtsuka, H. Rumpf, W. B. Knowlton, *P. Müllner*, "Mechanical, magnetic and magneto-mechanical properties of Ni-Mn-Ga magnetic shape-memory alloy thin films", Gordon Research Conference on 'Thin Film and Small Scale Mechanical Behavior', Waterville, Main, July 30-August 4 2006, without proceedings.

C36 *D. Mukherji*, M. Aguirre, P. Müllner, and G. Kostorz, "Electron diffraction and HREM imaging of the martensitic phase in Ni_2MnGa", MRS symposium 'Multiferroic materials', MRS-Fall-Meeting 2005, Boston, November 27-December 1, 2005, without proceedings.

C35 *M. Aguirre*, D. Mukherji, P. Müllner, and G. Kostorz, "High resolution TEM analysis of structure and microstructure of Ni-Mn-Ga alloys", Int. Workshop on 'Magnetic Shape Memory Alloys', Ascona, Switzerland, September 11-16 2005, without proceedings.

C34 *M. Hagler*, P. Müllner, W. B. Knowlton, A. Punnoose, M. Aguirre, and G. Kostorz, "Magneto-mechanical properties of Ni-Mn-Ga with different microstructures", Int. Workshop on 'Magnetic Shape Memory Alloys', Ascona, Switzerland, September 11-16 2005, without proceedings.

C33 *Z. Clark*, W. B. Knowlton, P. Müllner, M. Aguirre, and G. Kostorz, "Nano-magneto-mechanics of Ni-Mn-Ga Heusler Alloys", Int. Workshop on 'Magnetic Shape Memory Alloys', Ascona, Switzerland, September 11-16 2005, without proceedings.

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SUMMARY PROPOSAL BUDGET

Name of Institution: Boise State University

Name of Project Director: Dr. Peter Mullner

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

Name/ Title	Salary/Rate of Pay	Fringe	Dollar Amount Requested
Dr. Peter Mullner, Professor and Department Chair, .25 months	$169,084 for 12 mos.	27%	$4,474
Dr. Nader Rafla, Associate Professor, .25 months	$87,090 for 9 mos.	33%	$3,217
Graduate Research Assistant, .75 time	$18,000 for 12 mos.	4% academic year & 10% summer	$18,990
Undergraduate Research Assistant, approximately 600 hours	$11-$12/hour for 12 mos.	4% academic year & 10% summer	$6,969

% OF TOTAL BUDGET:	67%	SUBTOTAL:	$33,650

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

Item/Description	Dollar Amount Requested
SUBTOTAL:	

G. TRAVEL:

Dates of Travel (from/to)	No. of Persons	Total Days	Transportation	Lodging	Per Diem	Dollar Amount Requested
To be determined / travel to meet with industry partners	1-2	2-3				$600
SUBTOTAL:						$600

H. Participant Support Costs:

	Dollar Amount Requested
1. Stipends	
4. Other	

SUBTOTAL:	$0

I. Other Direct Costs:	Dollar Amount Requested
1. Materials and Supplies	$3,500
2. Publication Costs/Page Charges	$300
3. Consultant Services (Include Travel Expenses)	
4. Computer Services	
5. Subcontracts	
6. Other (specify nature & breakdown if over $1000) Analytical Fees (Boise State Center for Materials Characterization), estimated at 120 hours of usage @ $35/hr	$4,200
Graduate Student Fee Remission ; 75% of full tuition	$7,750
SUBTOTAL:	$15,750

J. Total Costs: (Add subtotals, sections A through I)	**TOTAL:**	$50,000
K. Amount Requested:	**TOTAL:**	$50,000

Project Director's Signature:	Date: 6/10/14

INSTITUTIONAL AND OTHER SECTOR SUPPORT
(add additional pages as necessary)

A. INSTITUTIONAL / OTHER SECTOR DOLLARS

Source / Description	Amount

B. FACULTY / STAFF POSITIONS

Description
PhD Student Graduate Research Assistant (stipend, tuition and fees) Undergraduate Research Assistant Partial funding for an Assistant Research Professor

C. CAPITAL EQUIPMENT

Description

D. FACILITIES & INSTRUMENTATION (Description)

Fully equipped laboratories (see Appendix 1)