Idaho Incubation Fund Program

Progress Report Form

Proposal No.	**IF14-005**
Name:	**Peter Müllner**
Name of Institution:	**Boise State University**
Project Title:	**Integral 3-D strain sensor**
Reporting Period:	**January 1-June 30, 2014**

Information to be reported in your progress report is as follows (attach additional information as needed):

1. Summary of project accomplishments for the period just completed and plans for the coming reporting period:

   a) *Activities for identifying industry partners*: We submitted a proposal to the NSF with two industry partners (see section 6 for details).

   The kick-off meeting of MSM-Net is scheduled for the ACTUATOR 2014 conference June 23-25, 2014, in Bremen, Germany. The purpose of MSM-Net is to connect researchers and industrial developers and bringing our technology to the market. We have invited 10 core members. Müllner will co-chair this meeting on June 25, 2014.

   b) *Research activities*: We oriented Ni-Mn-Ga single crystal powders in a magnetic field and determined the switching fields in well-defined orientations which was 200 mT. From these powders, we produced Ni-Mn-Ga composites by curing the elastomer/Ni-Mn-Ga mixtures in a magnetic field. The magnetic field aligned the powder particles with the crystallographic c direction parallel to the magnetic field. At the same time, the magnetic field aligned particles in lines. We then performed in-situ x-ray diffraction experiments where the Ni-Mn-Ga/elastomer composite was deformed while scattered x-ray intensity was recorded. During the deformation experiment, the intensity of the 004 reflection decreased and the intensity of the 400 reflection increased until the ratio of these intensities had reversed. This result confirmed the strain induced motion of twin boundaries which interchanges the 100 and 001 directions, and provides a prove of concept of using Ni-Mn-Ga/elastomer composites as transducers for strain sensors.

   c) *Plans for coming reporting period*: For the experiments described above, we used an elastomer which is transparent to x-rays, thus enabling the x-ray experiments. For the strain sensor, we will use elastomer with filler which diffracts at the same Bragg angles as Ni-Mn-Ga. We will produce such Ni-Mn-Ga/elastomer composites with various powder volume fraction and stiffness. We will characterize twin mobility via mechanical and magnetic testing. Upon successful demonstration of twinning, we will assemble a 1-D strain sensor with one double-coil and demonstrate strain-induced change of inductance. Upon successful demonstration, we will build a 3-D sensor.

In parallel with assembling and testing 1-D and 3-D sensors, we will continue improving powder quality. Powder processing will be optimized to obtain homogeneous powders with low twinning stress. Experiments will include characterization of individual powder particles and global characterization via x-ray diffraction.

2. Summary of budget expenditures for the period just completed (include project burn rate):

To date (i.e. April 30, 2014), we have spent $33,822 and the current (April 2014) burn rate is $7,330 per month. The current remaining balance is $11,928. We expect to have the project funds fully spent by the end of the project period (i.e. June 30, 2014).

3. Numbers of faculty and student participation resulting from the funding, including internships:

Three faculty (Dr. Peter Müllner, PI; Dr. Nader Rafla, co-PI; Dr. Paul Lindquist, assistant research professor), one graduate student (Tony Hobza, Materials Science and Engineering), and one undergraduate student (Charles Patrick, Electrical Engineering) participate in the project.

4. List patents, copyrights, plant variety protection certificates received or pending:

K. Ullakko, K. Sasaki, P. Müllner, “Sensor Device”, Non-Provisional Application for United States Letters Patent.

5. List technology licenses signed and start-up businesses created:

Dr. Paul Lindquist incorporated MP Research LLC on May 7, 2014. Regarding magnetic shape memory alloys MP Research’s focus is to commercialize the actuator/sensing element by shrinking its’ size via processing the alloys as powders or fibers. The main advantage of this approach is to significantly reduce the cost of an individual MSMA element and the time needed to produce an element. At the same time MP Research will build proof-of-concept prototypes of sensors and actuators that demonstrate the feasibility of using micro magneto-mechanical elements like this. MP Research is also seeking partners to scale up the prototypes for high volume manufacturing.

6. Status of private/industry partnerships (include enough information to judge level of engagement):

In January 2014, we submitted a proposal *Smart Material Machine Medical Service Delivery* to the NSF request for proposals 13-587 Partnership for Innovation: Building Innovation Capacity. Two companies headquartered in the Treasure Valley are partners in this project: Teton Machine Co (Payette, ID) and WestVet (Boise, ID). The proposal

is pending.

We are in the process of establishing a fee schedule for MP Research LLC such that MP Research LLC can access Boise State University facilities.

7. Any other pertinent information that will indicate to the council that the project is meeting satisfactory progress.

On April 2, 2014, we submitted a proposal Instrument Mechanisms using Magnetic Shape Memory Alloys to the NASA ROSES request for proposals NNH13ZDA001N-ACT. We propose to develop a series of improved mechanisms typically used on earth science instruments based on Magnetic Shape Memory Alloy (MSMA) technology in a collaborative effort with the Goddard Space Flight Center (GSFC). Our direct project partner, Jason Budinoff is located in Boise, ID, and aims to develop manufacturing capabilities for space flight devices in Southern Idaho.

At the end of April, we submitted a letter of intent to the Walmart foundation's *Walmart U. S. Manufacturing Innovation Fund* in response to the foundation's request for proposal of March 13, 2014. We proposed the project Magnetic Shape Memory Technology for Smaller and Simpler Motor Design and Assembly for which we intend to request $2.4 million. If invited to submit a full proposal, the proposal will be due in August 2014.