Idaho Incubation Fund Program

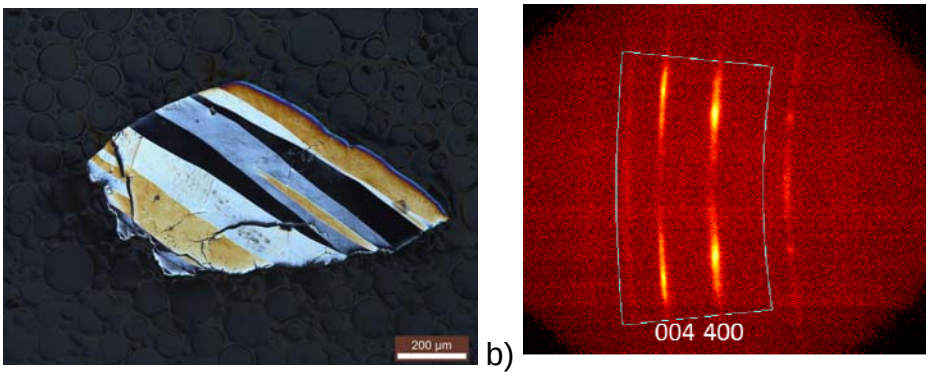
Progress Report Form

Proposal No.	**IF15-003**
Name:	**Peter Mullner (PI)**
Name of Institution:	**Boise State University**
Project Title:	**Integral 3D Strain Sensor Phase II**
Reporting Period:	**July 1, 2014 to December 22, 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:*
   The senor consists of a magnetic shape memory alloy/polymer composite and a set of drive and pic-up coils. During the first project year (i.e. phase I), we demonstrated fabrication of the composite material and to some extend the deformation-induced rearrangement of twin domains. We also demonstrated the sensing principle on a Ni-Mn-Ga single crystal.

   During the reporting period, we improved the quality of powder particles and the effectiveness of the sensing principle. Figure 1a) shows a single crystal powder particle with one set of twin boundaries. The particle was oriented in a magnetic field, embedded in a raisin, and then polished. To orient the samples, we built a set of Helmholtz coils which we run with a 1500 W power supply. The x-ray diffraction pattern (Fig. 1b) demonstrates that the polished surface was within a few degrees parallel to {100}.



a) b)

Figure 1: Single crystalline Ni-Mn-Ga powders . (a) Optical micrograph of a powder particle with one set of twin boundaries. (b) x-ray diffraction results from a single powder particle demonstrating successful orientation

   We improved the resolution of the sensing apparatus with an analog to digital converter (U2542A) with high resolution and four channels to measure the induced voltage. Figure 2 shows the new experimental set-up and a diagram with input and

output variables.

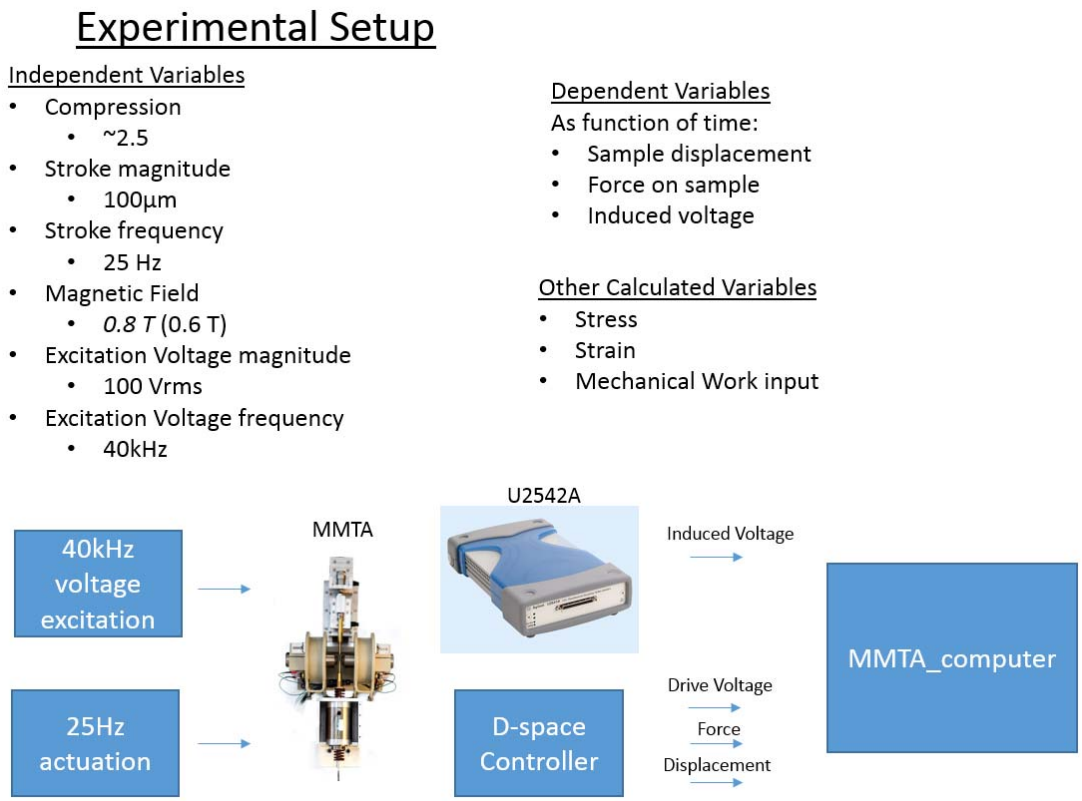


Figure 2: Experimental setup: a drive coil sends a 40 kHz signal which is sensed by the pick-up coil.

Figure 3a) shows the output signals recorded with the U2542A analog to digital converter. The output data include displacement, velocity, force, and voltage. From these data, the induced voltage can be plotted as a function of displacement (Fig. 3b).

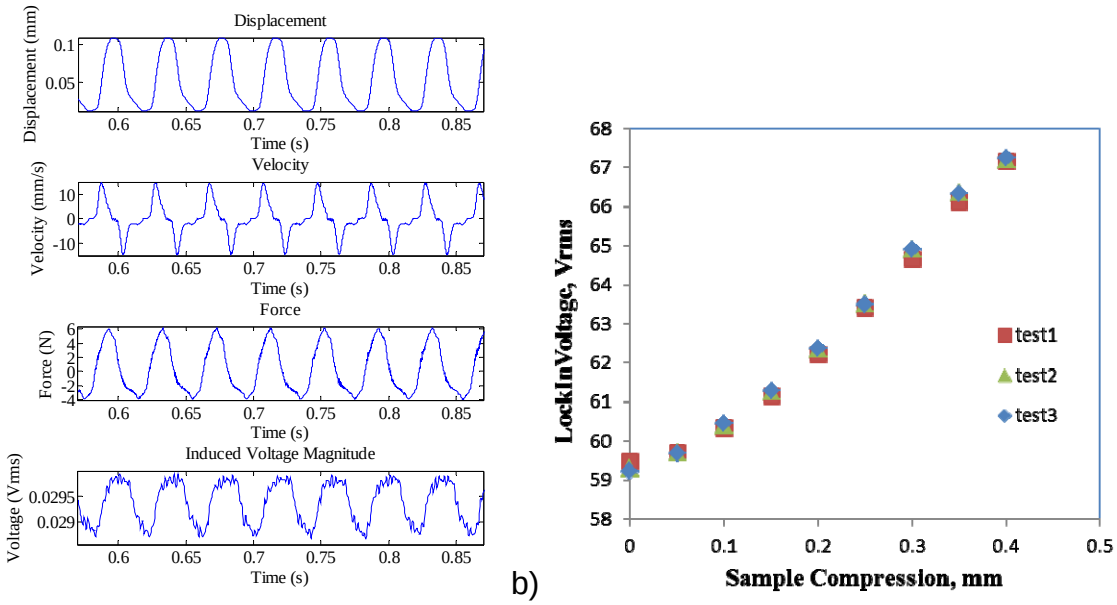


Fig. 3: (a) Output signals recorded with the experimental set-up shown in Figure 2. (b) Plot of the displacement and voltage data shown in (a).

During the next reporting period, we will measure the switching field of single crystal powder particles, embed the particles in a polymer matrix, demonstrate deformation induced twinning, and measure the induced voltage for the transducer composite material.

2. *Summary of budget expenditures for the period just completed (include project burn rate):*
   Salary and Fringe: $3,776.48 Supplies: $3,874.50 Burn Rate: 15.30%

3. *Numbers of faculty and student participation resulting from the funding, including internships:*
   Faculty involved: Dr. Peter Müllner (PI), Dr. Nader Rafla (co-PI)
   Students involved: Tony Hobza (PhD student), Charles Link Patrick (undergraduate student), Miranda Buttram (undergraduate student), Andrew Morrison (undergraduate student), Eric Rhoads (undergraduate student)

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:*
   N/A

6. *Status of private/industry partnerships (include enough information to judge level of engagement):*
   We are in contact with PM Research, which was incorporated by Dr. Paul Lindquist in spring 2014.

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

   We submitted the following proposals for technology development:

   (1) *Magnetic Shape Memory Technology for Smaller and Simpler Motor Design Assembly* (Projecdt Number 14627873); Walmart Foundation, amount requested: $2,600,000. Not funded.

   (2) *Motionless MSM Micropump*; NSF Partnership for Innovation: Accelerating Innovation Research – Technology Transfer, requested amount: $200,000. Pending.

   (3) *Proof of Concept Center for Market Acceptance of Idaho Techgnology: Driving the regional confidence required to commercialize disruptive technology and iterate towards high growth spin-off and job development*; Economic Development Administration, amount requested: $500,000. Pending.

   (4) *Large stroke low power magnetic shape memory actuators for space applications*; NASA-EPSCoR, amount requested: $706,500. Pre-proposal pending.