BOISE STATE UNIVERSITY

Impact of Micro-Peening on the Surface of Ni-Mn-Ga

P. Plaskonos[1,2], A. Armstrong[1], P. Müllner[1]

[1]Micron School of Materials Science and Engineering, Boise State University, Boise, ID

[2]Department of Materials Science and Engineering, North Carolina State University, Raleigh, NC

Magnetic Shape Memory Alloys

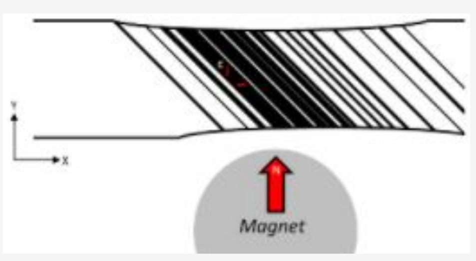


Figure 1: Localization of shrinkage in an MSMA under a stationary magnetic field.

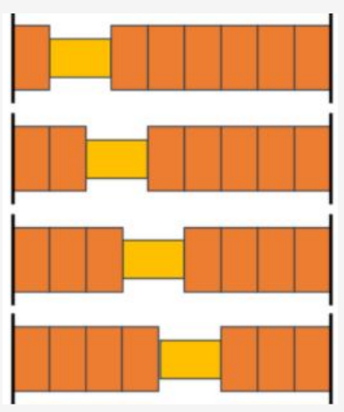


Figure 2: Movement of shrinkage in an MSMA under a rotating magnetic field.

- Magnetic shape memory alloys (MSMAs) change shape under a magnetic field and retain the shape after the field is removed.
- The shape change by moving twin boundaries, and a higher twin density leads to the element resisting failure.

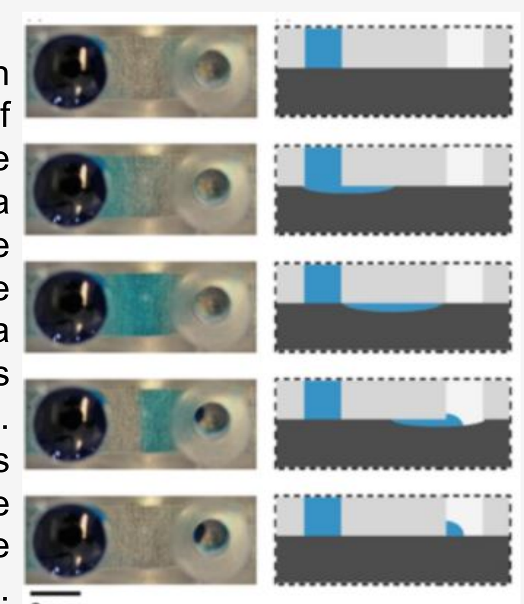
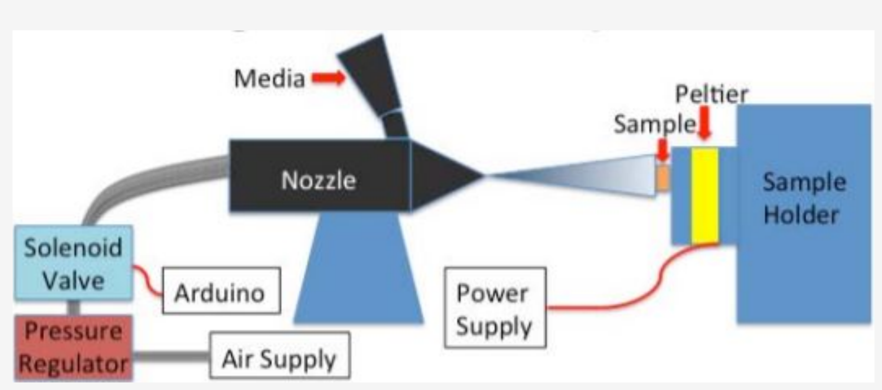


Figure 3: An application of MSMAs is the use of in a micropump. The shrinkage of the MSMA creates a cup that collects a volume of fluid. The cup moves along with the rotation of the magnetic field.

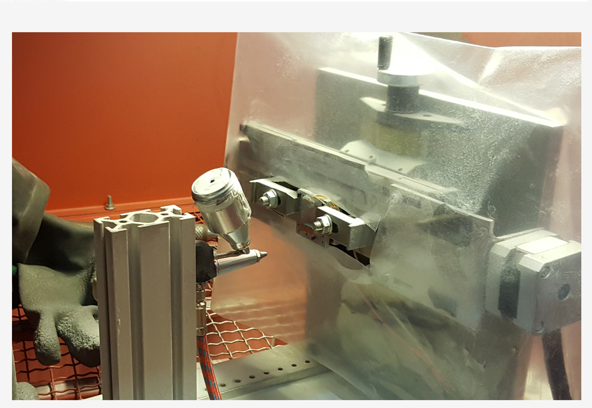
- By micro-peening surfaces, the density of twin boundaries likely increases.
- It is possible to over-treat and under-treat a surface.
- The goal of the experiment was to find the optimum surface treatment for the MSMA Ni-Mn-Ga.

Procedure

- Ni-Mn-Ga crystals were polished to 9 µm using a diamond slurry, which made the surfaces of the different crystals were similar prior to treatment.
- Treated using 50 µm glass media at pressures from 0.344 bar to 3.44 bar.
- Different areas of the crystal were exposed for different pressures, with the blaster at a constant distance of 40 mm.
- One crystal was treated in the Martensite phase, while the other was peened in the Austenite phase.
- The Austenite phase was created by heating the designated crystal to 80ºC prior to treatment.



Figures 4: A schematic of the micro-peening system used.



Figures 5: A image of the micro-peening equipment used for the experiment.

Surface Roughness

- Can be optically interpreted, but we also used quantitative methods to describe the surface.
- R_a is the arithmetic average of deviations from the mean line of the profile of the surface.
- Limitation: does not indicate how twin boundaries respond to surface treatment.

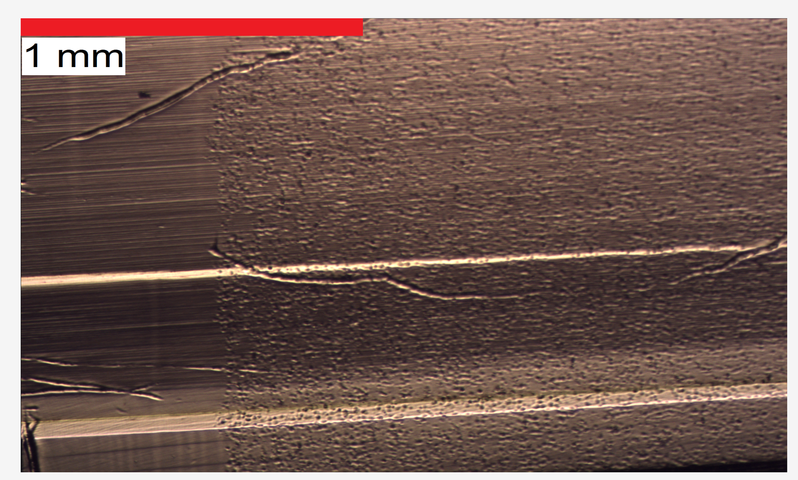


Figure 6: Optical micrograph of a partially peened sample (at 1.03 bar). Twins and surface imperfections are still visible.

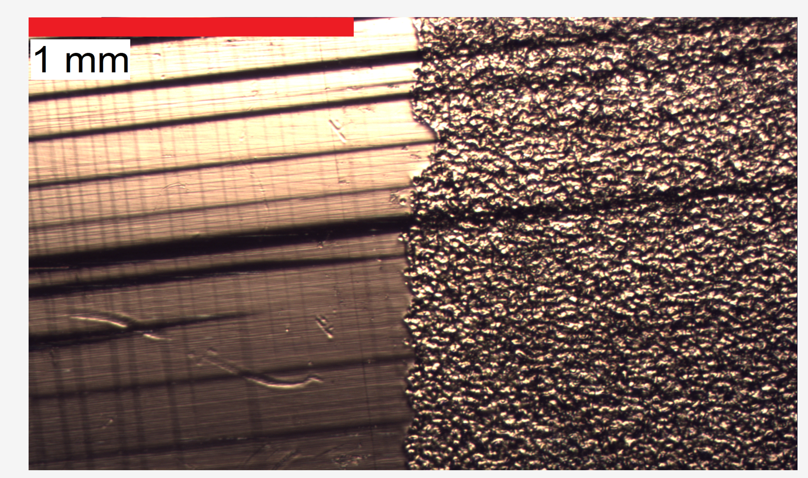


Figure 7: The contrast between an Austenite-peened region at 3.45 bar compared to a non-peened region. In the peened region, smaller twin boundaries and surface imperfections are not visible while larger twins are visible.

Results

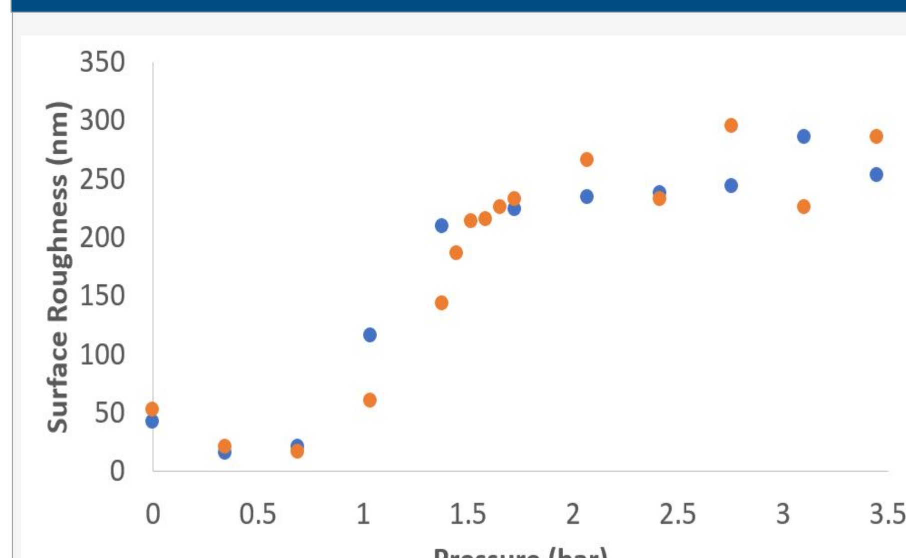


Figure 8: Surface roughness of samples peened at various pressures in different states, Martensite (orange) and Austenite (blue). The same trends are present when samples are peened in different states. Each point is an average of three measurements.

- The surface roughness was determined using a WYCO NT1100 optical profilometer.
- Martensite and Austenite crystals show similar surface response trends to treatment.

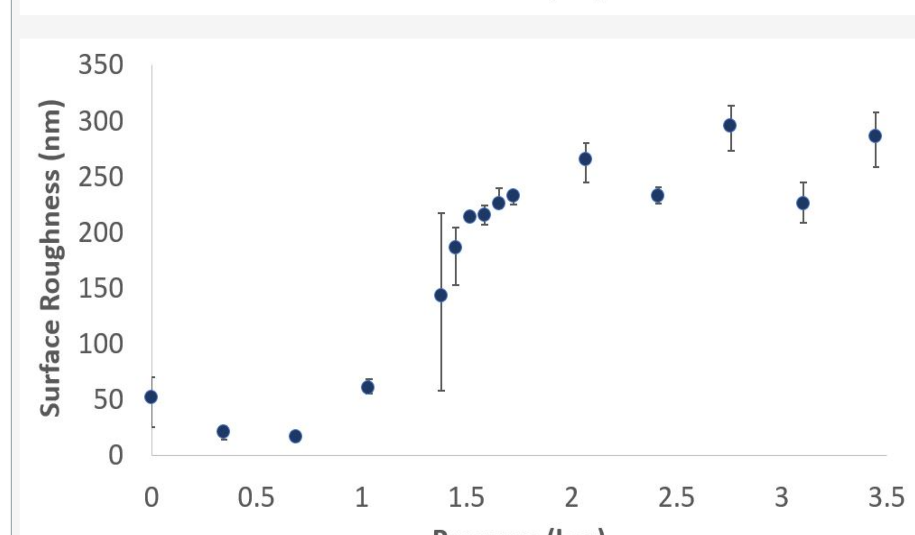
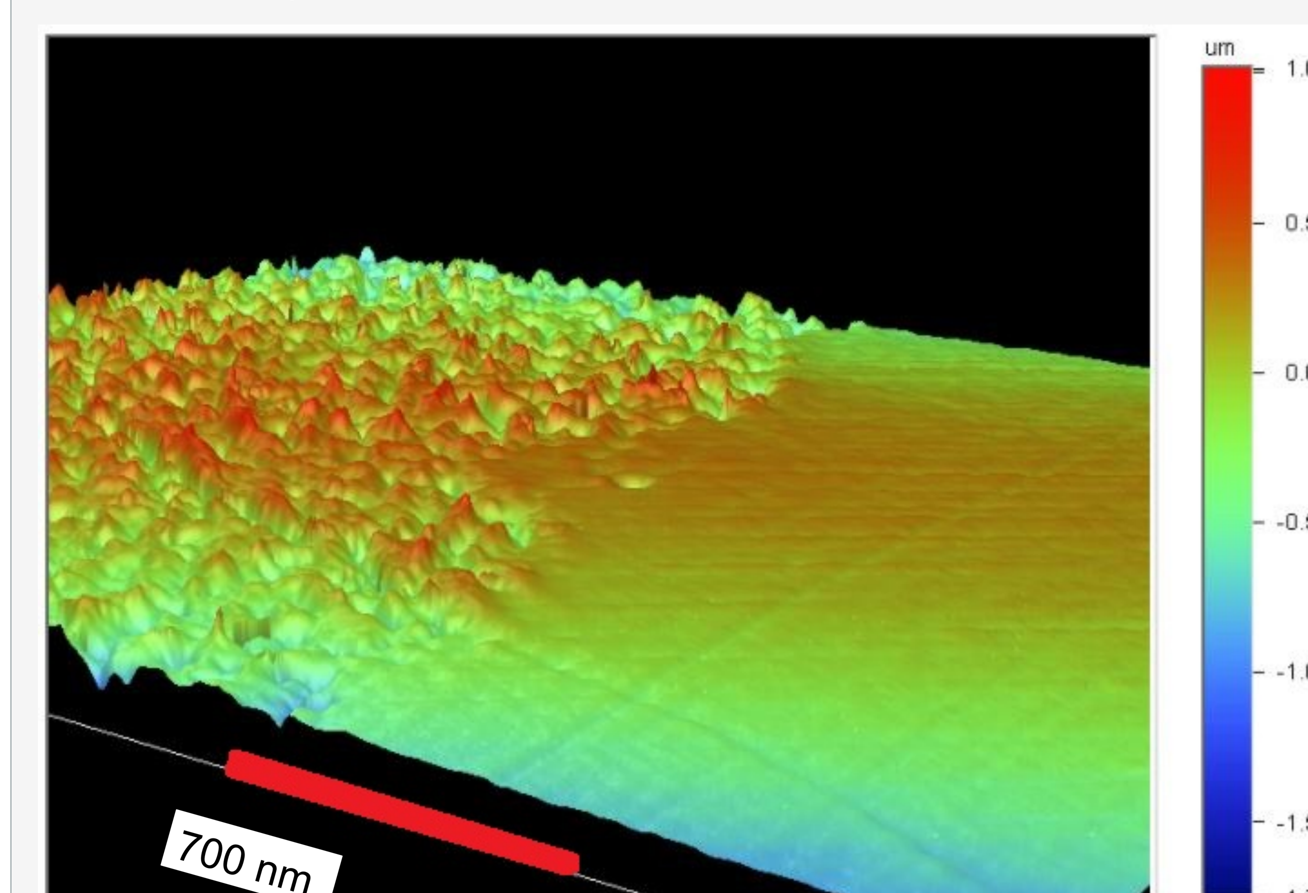


Figure 9: Surface roughness of Austenite-state peened samples at various pressures. The surface becomes evenly peened above 1.03 bar, and the roughness slightly increases and levels out above this point. Each point is an average of three measurements.

Conclusions and Future Work

- The Ni-Mn-Ga had a similar average surface response to the treatment in both of the phases.
- This correlation indicates that, from a surface roughness perspective, that there is no reason to micro-peen in one phase over the other.
- This information is valuable, but how the element interacts with varied magnetic field strengths is needed to optimize micropumps.
- The next step is to measure how these treatments respond to magnetic fields. This can be done by measuring switching fields of elements treated to the same specifications.
- Other factors to consider changing for the treatment process:
  - size of blasting media
  - time the sample is exposed to blasting media

Figure 10: Martensite-peened region at 1.38 bar contrasted with a non-peened region. Image produced with an optical profilometer. The non-peened region was masked with tape to maintain its structure.



Acknowledgements

We thank Travis Gabel for assistance with surface-profiling equipment.

This project was funded by the National Science Foundation through the Research Experience for Undergraduates Site: Materials for Society at Boise State University (DMR 1658076) and through the research grant STTR 1622856.