Performance of a Magnetic Shape Memory Micropump
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Introduction
- Solid-state micropumps - a promising market for point of care diagnostics, biomedical research and lab-on-a-chip test devices.
- Desirable features of micropump: free from electrical contacts, sealed within a potentially disposable lab-on-a-chip unit, pumping without ancillary mechanical devices, precise and sensitive over a wide range of volume, etc.

Magnetic shape memory (MSM) alloy Ni-Mn-Ga elements:
- Strain up to 6%, through twinning process, when exposed to a magnetic field.
- Allow for a wide range of precise volumes to be delivered.
- Magnetic field can be generated by an off-chip source

Mechanism
- Top view of MSM element with twins produced by a diametrically magnetized cylindrical magnet.
- Schematic side view of MSM element with twin structure of localized shrinkage.
- MSMA micropump pumping: the magnetic field creates a cavity on the MSMA element. The cavity moves along the MSM element upon rotation of the cylindrical magnet and transports fluid.

Objective /Design
Objective: to carry out systematic experiments measuring the pumping flow rate as a function of rotational speed of the magnet.

Experimental Procedures/Results
- Performed experiments to test efficiency of the MSM micropump.
- Diametrically magnetized cylindrical magnet was turned by a drill for approximate 4s.
- Magnified view of MSM micropump moving water from left to right.
- The MSM micropump successfully pumped water in both directions.
- When moved forward to test flow rate of MSM micropump, MSM element cracked.
- Multiple cracks formed indicating that the damage was not due to mechanical overload.
- SEM images of fracture surface of the MSM element exhibit ripples which may correlate with twins.

Conclusions/Discussion
- Constructed micropump by a single component Ni-Mn-Ga element.
- MSMA micropump successfully delivered a drop of water (=0.05ml) in both directions.
- Failure of the MSM element could be caused by following reasons:
  - Impurity of the MSM element.
  - Turning magnet by a drill made twins move, and it also caused the MSM micropump vibrate.
- Fatigue life of Ni-Mn-Ga is varied from 4,000 cycles to 800,000 cycles. After Ni-Mn-Ga elements have been cycled many times, twinning activity would be reduced.

Future Work
- Determine Fatigue life of Ni-Mn-Ga magnetic shape memory alloys.
- Prevent any sealants (Epoxy, Silicone and Sylgard) from leaking into MSM element to help render micropumps effective.
- Fasten diametrically magnetized cylindrical magnet right under MSM element to help increase efficiency of twins motion.
- Characterize flow rate, pressure, temperature and power consumption of MSMA micropumps.

References
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