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Magnetic Shape Memory Micro-Pump for Intra-Cranial Drug Delivery

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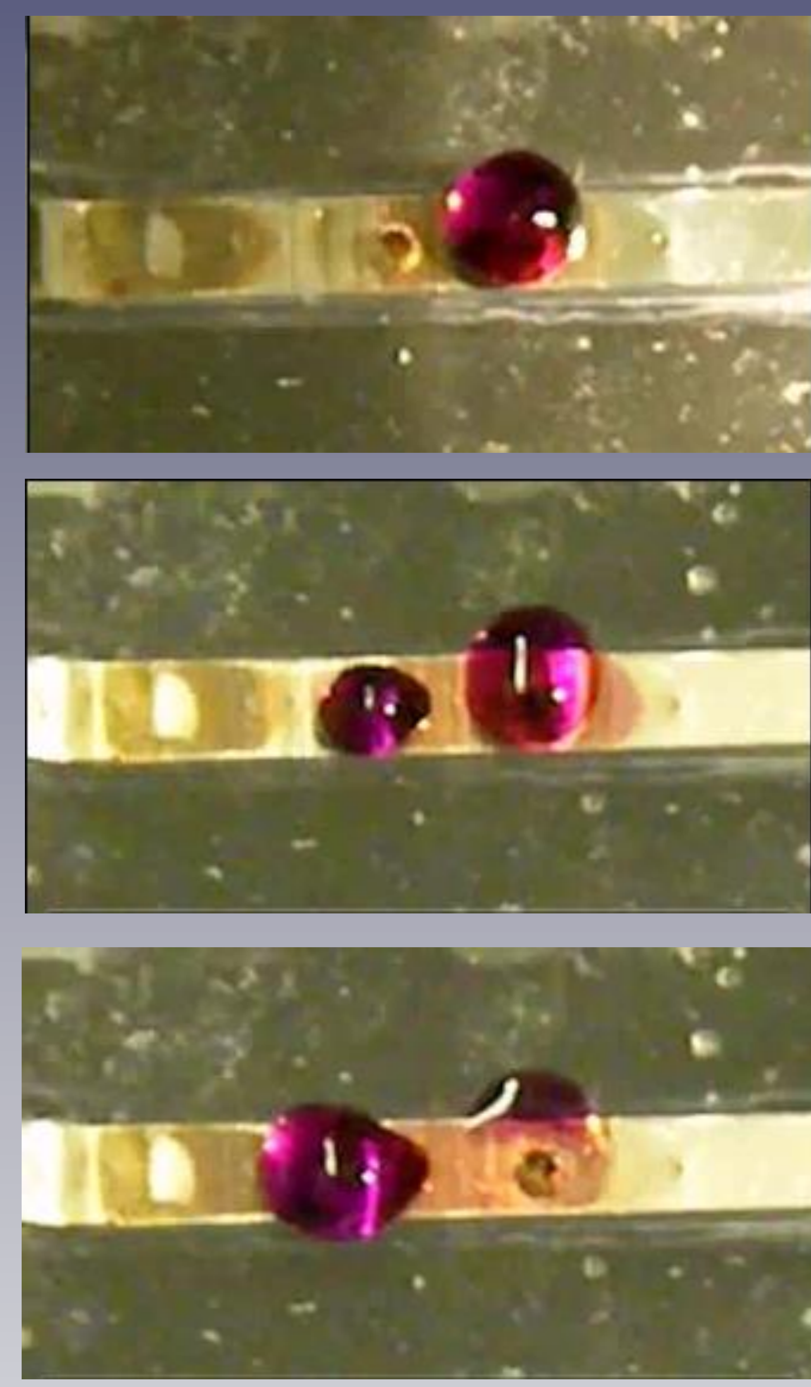
PURPOSE

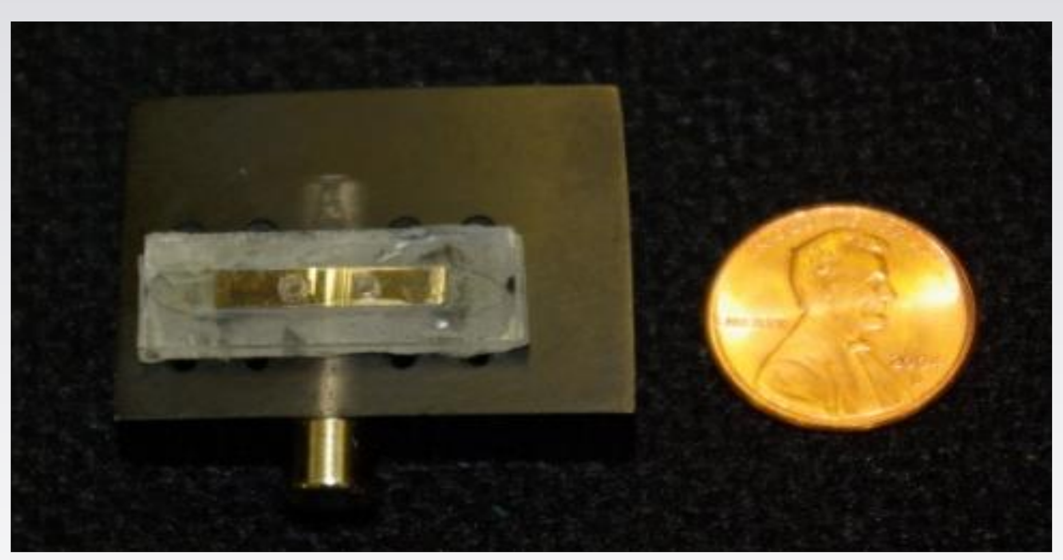
Single crystal Ni-Mn-Ga magnetic shape memory alloys (MSMAs) exhibit magnetic field induced strain (MFIS) of up to 10%. The MFIS is the result of the reorientation of martensitic twins.

Ni-Mn-Ga alloys can be used as non-contact actuators or sensors. The Ni-Mn-Ga alloy has previously been applied as a functional actuator in a micro-pump which relocated small amounts of liquid from one opening to another.

Presently we have developed a micropump to deliver sub-micro liter quantities of drugs directly into the brain of laboratory rats. This pump will be integrated in a head stage in parallel with EEG and other bio-sensors.



Previous prototype moving liquid from right to left over a rotating magnet
K. Ullakko, L. Wendell, A. Smith, P. Mullner, G. Hampikian, Smart. Mater. Struct. 21 (2012) 115020



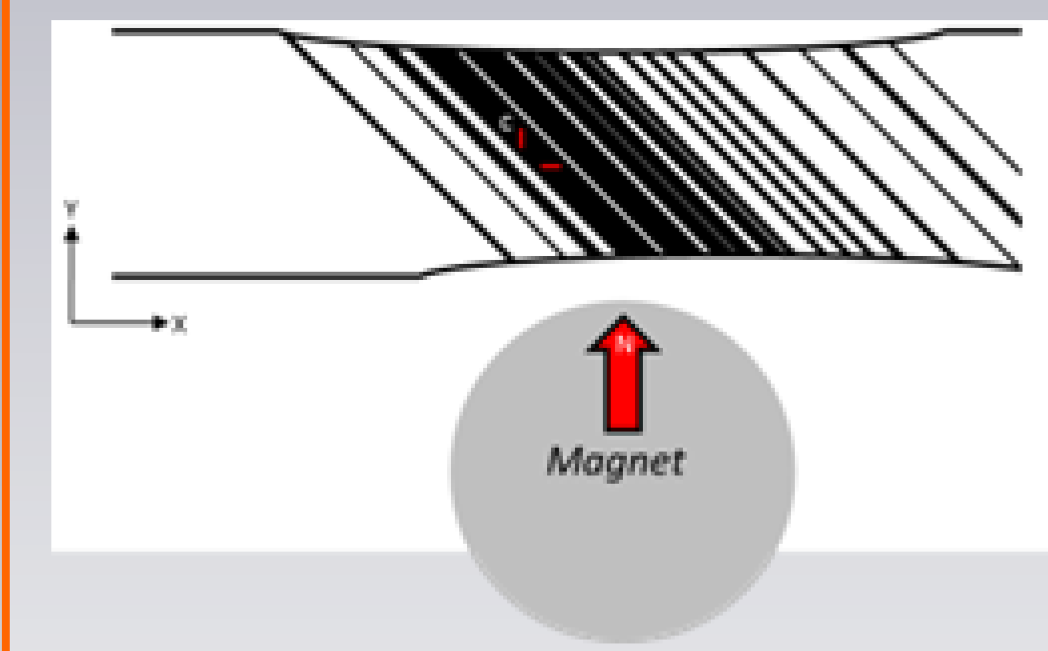
Previous Prototype
Without Motor

Current Prototype
With Motor/reduction gear and Enclosure

Working Mechanism

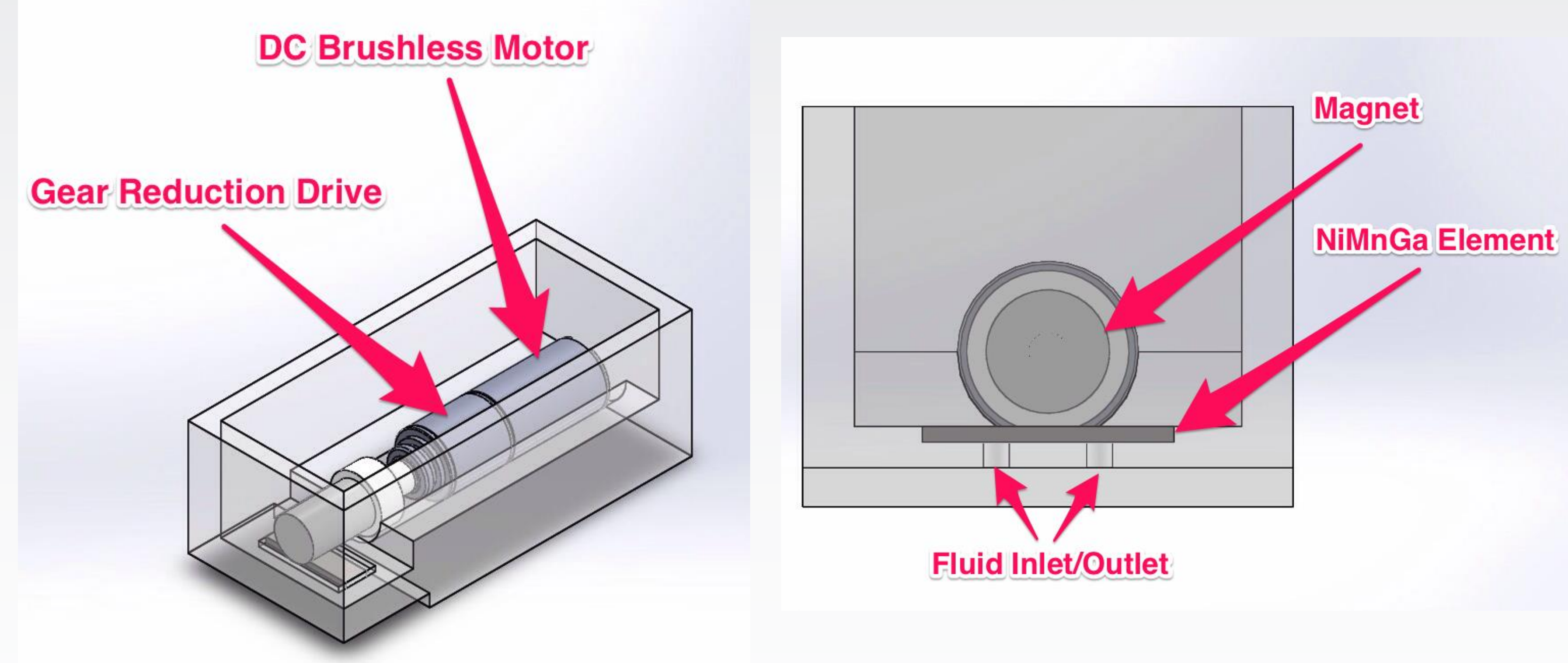
Twins and Shrinkage Formed by Localized Magnetic Field

Top view of MSMA element with twins (dark bands) positioned above cylindrical magnet



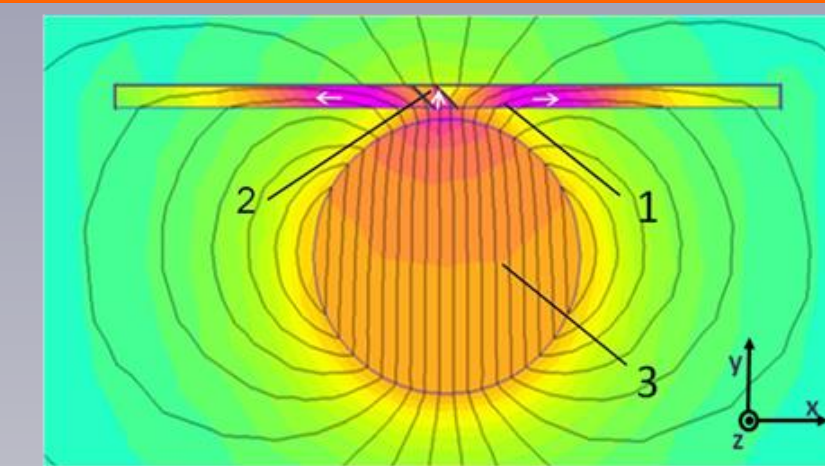
Schematic of the cross-section with twins producing localized shrinkage

A diametrically magnetized rare-earth magnet is placed on one side of the MSM element. The perpendicular field orients twins to produce localized shrinkage. The shrinkage moves down the length of the element as the magnet rotates.
K. Ullakko, L. Wendell, A. Smith, P. Mullner, G. Hampikian, Smart. Mater. Struct. 21 (2012) 115020.

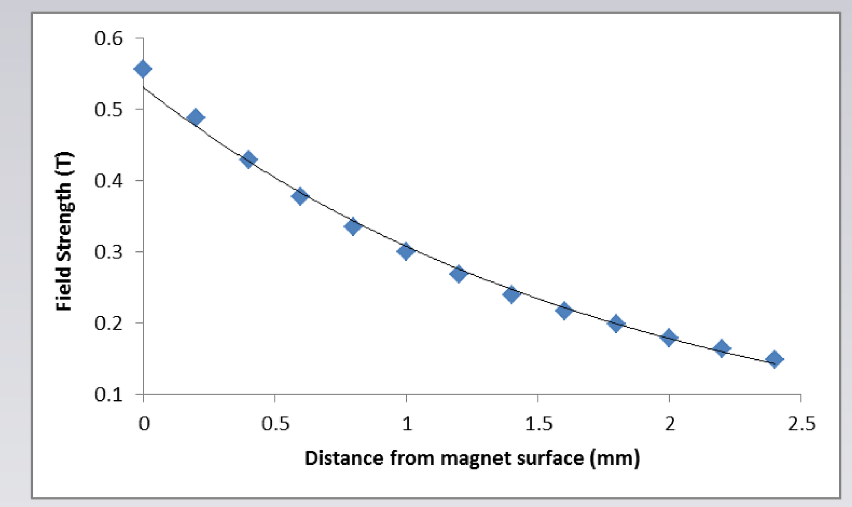


3D render of current prototype

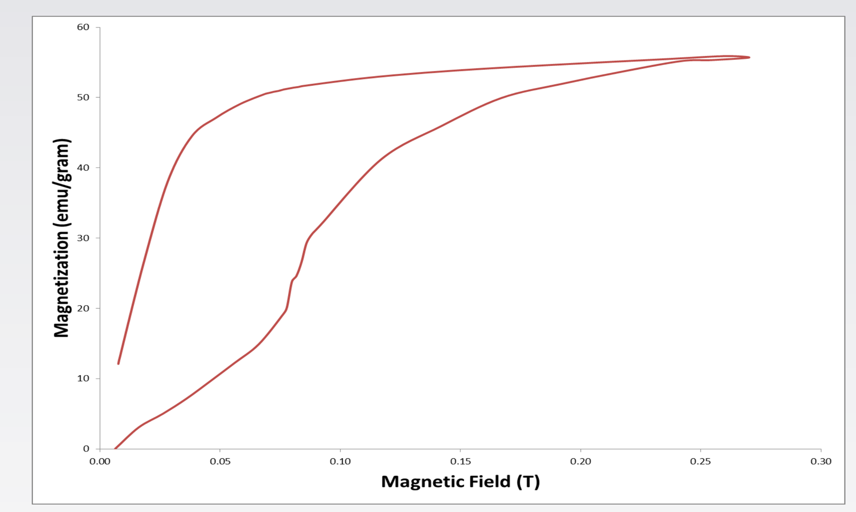
Magnetic Characterization



Magnetic field lines in a MSMA bar (1) with a twin (2) placed above a cylindrical magnet (3)
K. Ullakko, L. Wendell, A. Smith, P. Mullner, G. Hampikian, Smart. Mater. Struct. 21 (2012) 115020.



Permanent magnet field at a distance



Element CM162C1 Switching Field

Goals & Future Work

- Achieve flow rate of 0.2 μL/Min
- Prototype delivery to University of Birmingham, U.K. in June 2014
- Further miniaturization and mass reduction
- Replace 7mm motor with 4mm version

ACKNOWLEDGEMENTS

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