SMART actuators with sensing ability based on Heusler microwires.

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RVmagnetics
When size matters

CPM TIP, UPJS

Advantages of wire shape actuators

(motivation)

Shape anisotropy

Enhancement of functionality in a single direction

Straining in a single direction

Surface / Volume fraction

Low eddy current

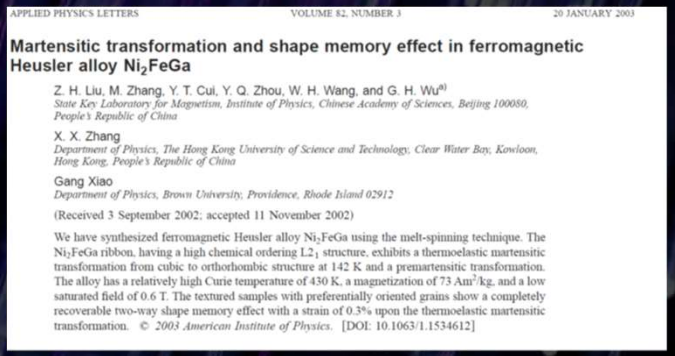
Simple production of large amount

Simple processing in applications

Heusler microwires for shape memory applications

The biggest problem is Mn

Novel composition $Ni_{50}Fe_{25}Ga_{25}$



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Martensitic transformation and shape memory effect in ferromagnetic Heusler alloy Ni_2FeGa

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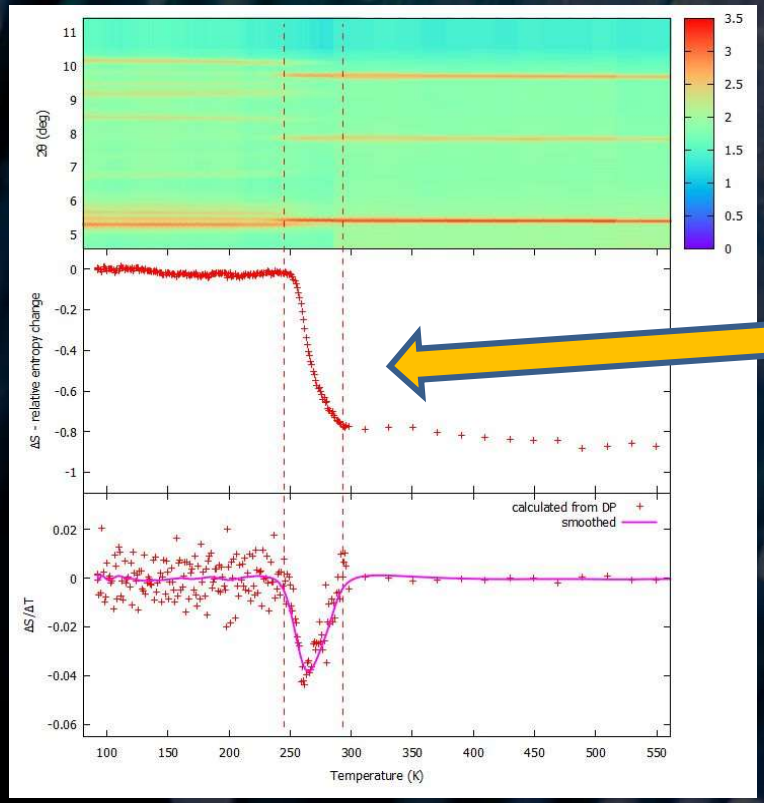
We have synthesized ferromagnetic Heusler alloy Ni_2FeGa using the melt-spinning technique. The Ni_2FeGa ribbon, having a high chemical ordering $L2_1$ structure, exhibits a thermoelastic martensitic transformation from cubic to orthorhombic structure at 142 K and a premartensitic transformation. The alloy has a relatively high Curie temperature of 430 K, a magnetization of 73 Am^2/kg, and a low saturated field of 0.6 T. The textured samples with preferentially oriented grains show a completely recoverable two-way shape memory effect with a strain of 0.3% upon the thermoelastic martensitic transformation. © *2003 American Institute of Physics*. [DOI: 10.1063/1.1534612]

Energy Dispersive X-ray (EDX) analysis:

$Ni_{50.03}Fe_{25.36}Ga_{24.61}$ (at.%)

Heusler microwires for shape memory applications

$Ni_{50}Fe_{25}Ga_{25}$



High temperature Austenite

a=5.756 Å

Phase transition between 240-290 K

Low temperature- monoclinic

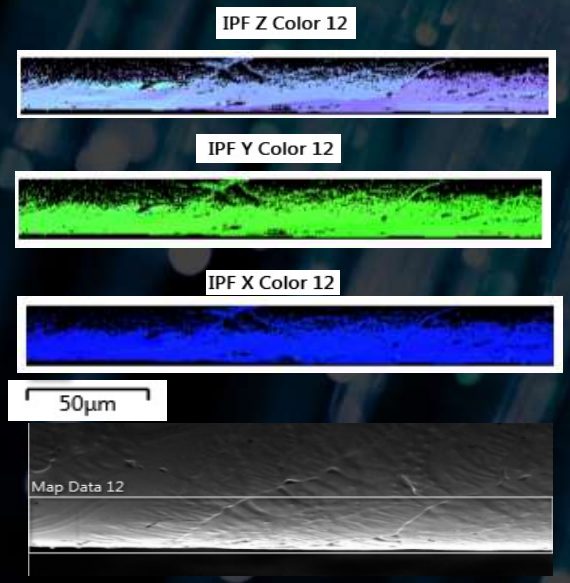
a=4.1593Å, b=5.3767Å, c=20.7616Å

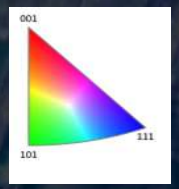
β=86.734°

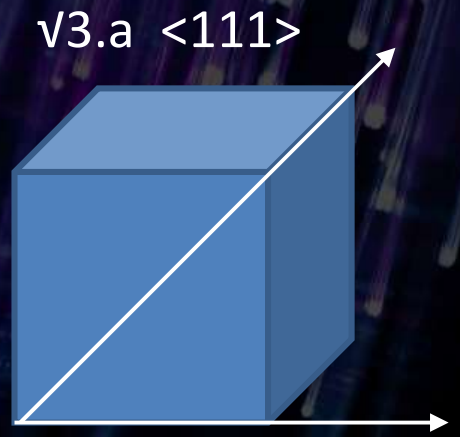
Heusler microwires for shape memory applications

$Ni_{50}Fe_{25}Ga_{25}$

Monocrystalline structure !!!





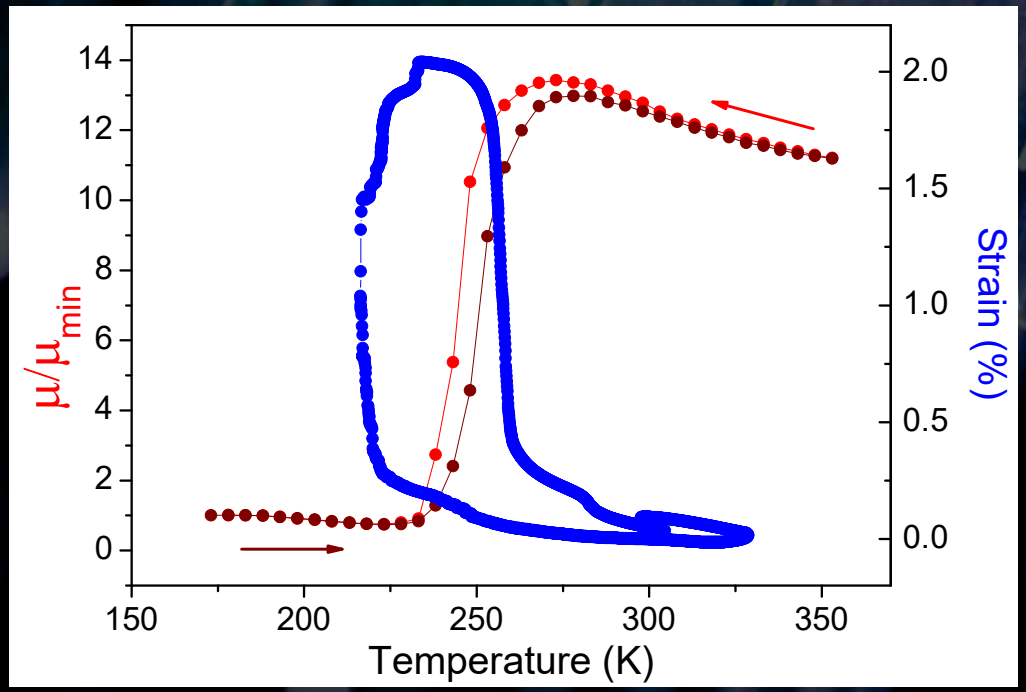


Strong stresses due to glass can be released by orientation of crystal lattice

<111> direction // wire's axis

Heusler microwires for shape memory applications

$Ni_{50}Fe_{25}Ga_{25}$



Dynamic Mechanical Analyzer (DMA) analysis

Reversible Phase transition

Maximum strain 2%

But also 1200 % variation of permeability

SMART actuator

Heusler microwires for shape memory applications

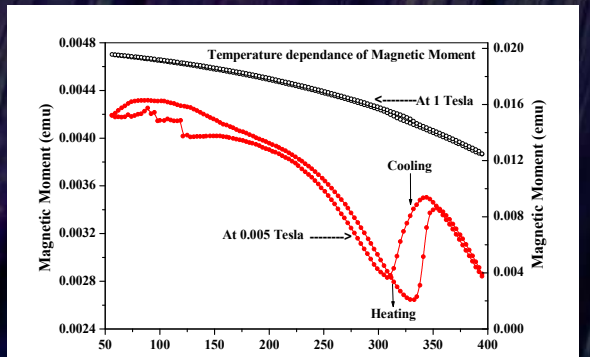
$Ni_{50}Fe_{27}Ga_{23}$

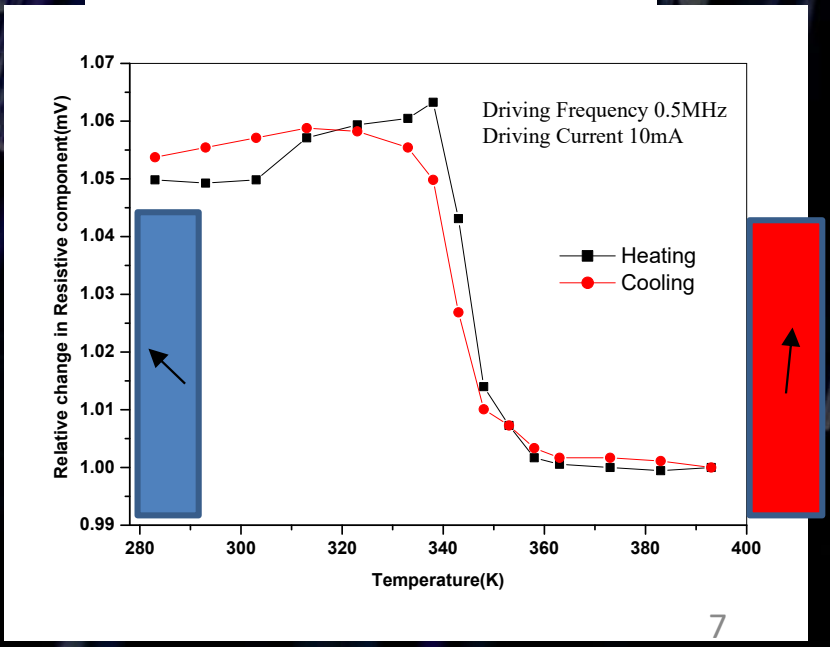
Using Giant MagnetoImpedance (GMI) for sensing

Easy axis change =>
permeability change =>

GMI change

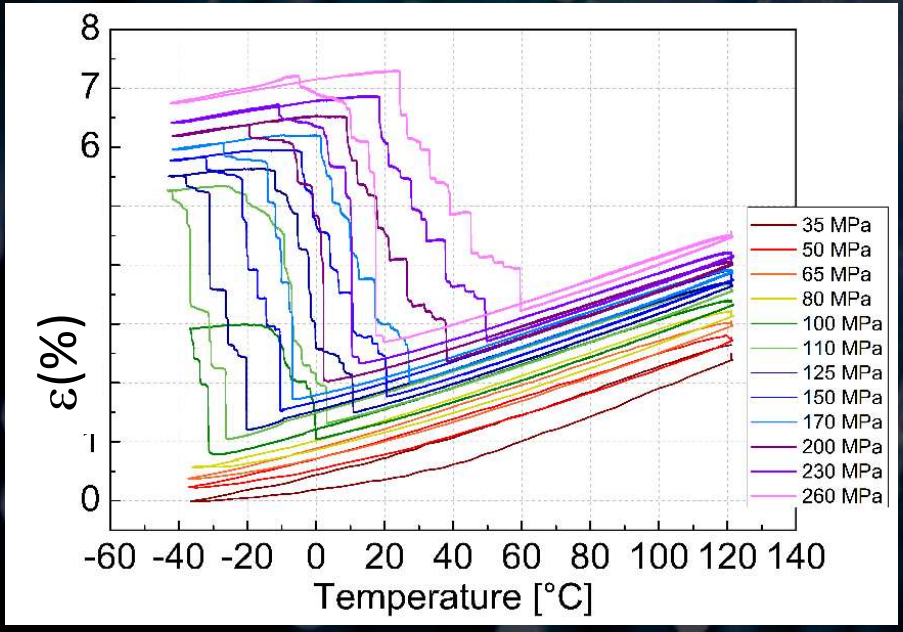
Smaller variation of GMI,
but clearly recognized and
easier for applications





Heusler microwires for shape memory applications

$Ni_{50}Fe_{25}Ga_{25}$



Stress application =>

Reversible Phase transition

Maximum strain over 4%

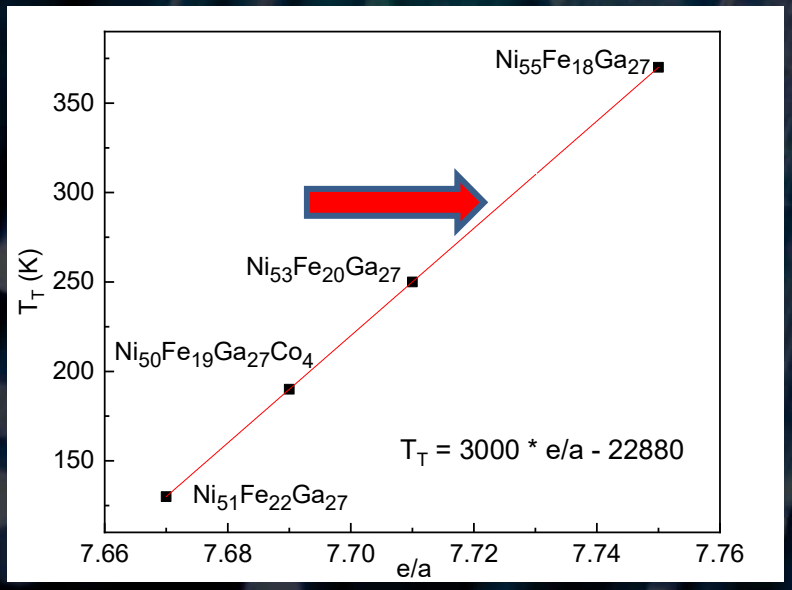
Adjustment of Transformation temperature

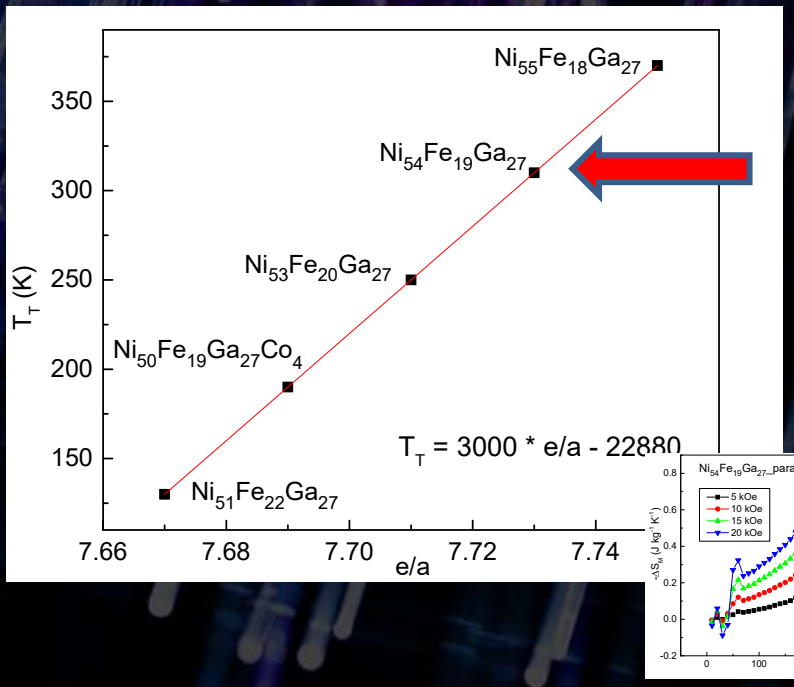
260MPa(Φ ~ 100µm) ~ 800g

Heusler microwires for shape memory/magnetocaloric applications

$Ni_{55-x}Fe_{18+x}Ga_{27}$

Phase transition temperature depends on e/a

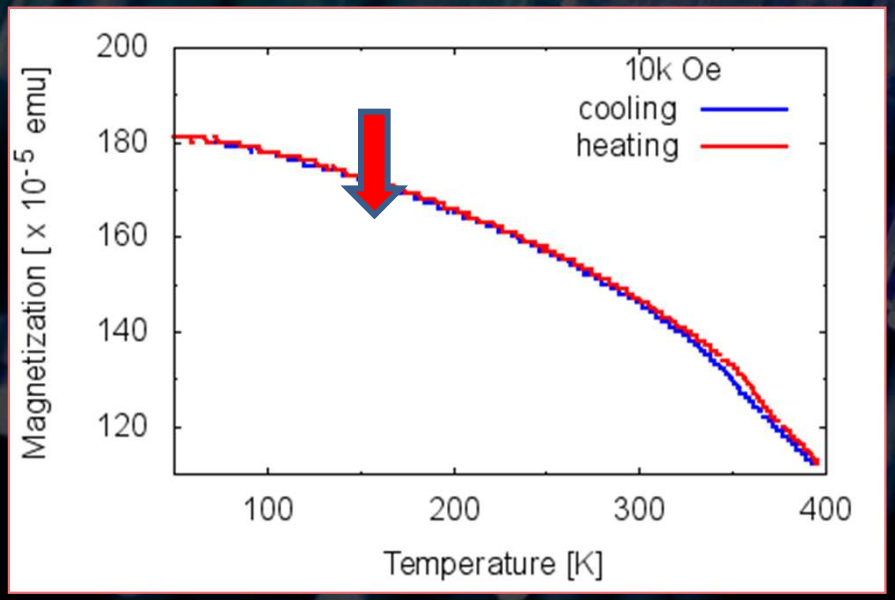




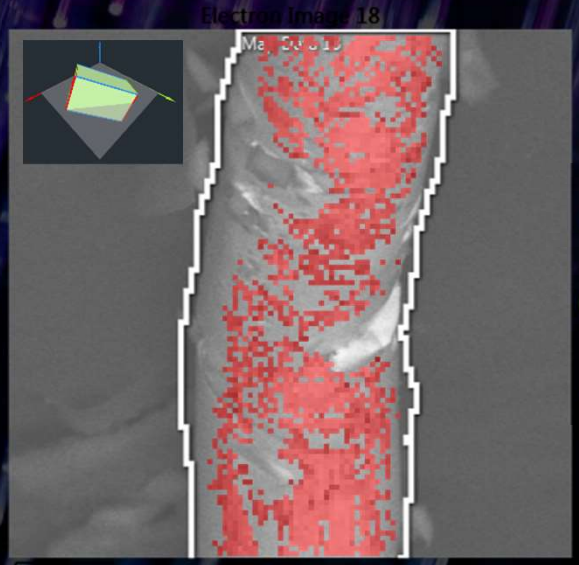
Heusler microwires for shape memory

$Ni_{50}Fe_{27}Ga_{23}$

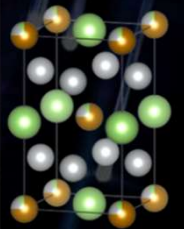
Transition~ 320-380K



Monocrystalline

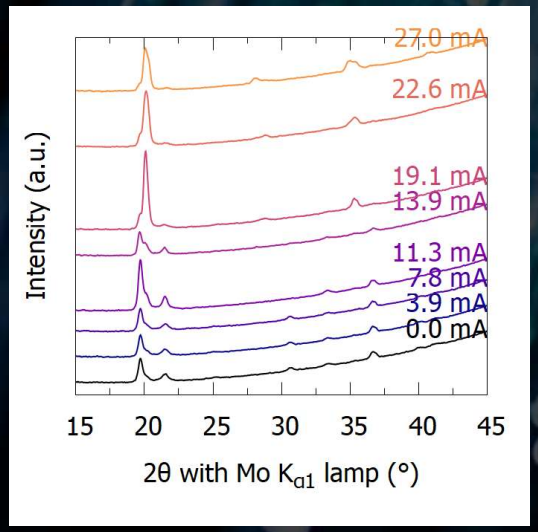


NM



Heusler microwires for shape memory

$Ni_{50}Fe_{27}Ga_{23}$

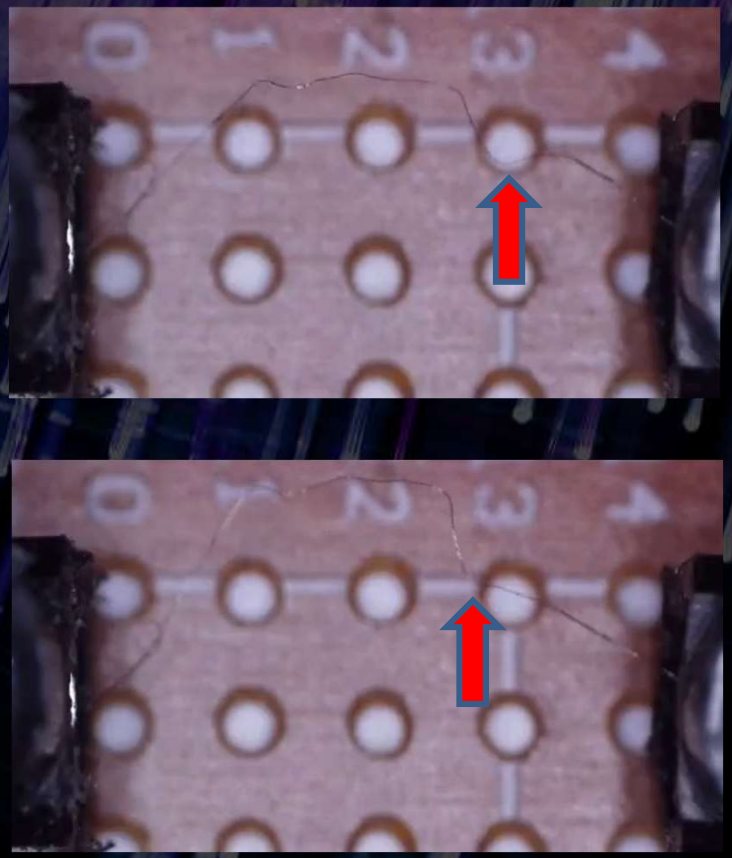


Heated by el. current

Repetitive cycling over 1 000 000 times

at 1Hz

i_{AC}~ 30mA

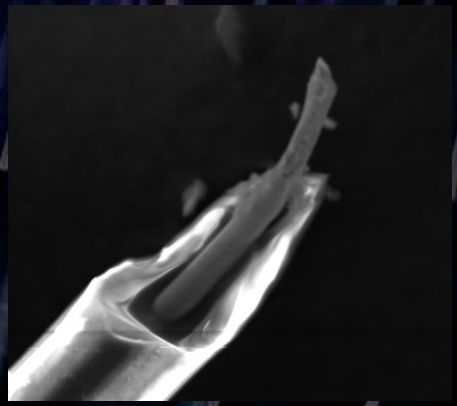


Strain >20%

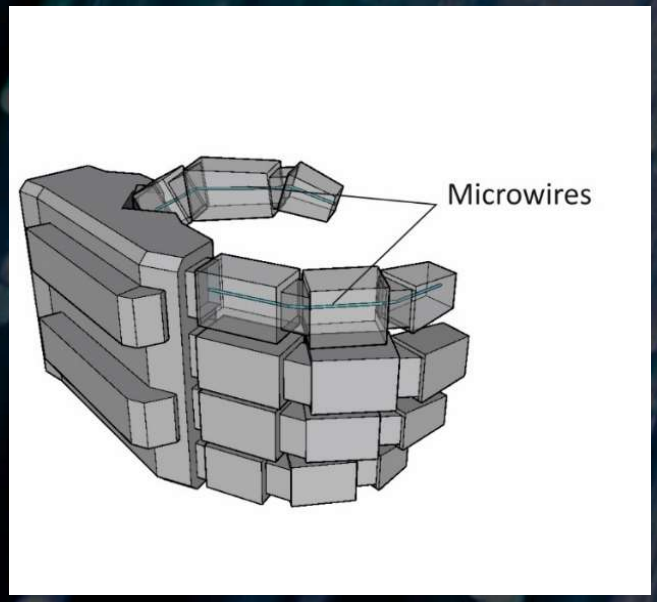
Summary

Ni-Fe-Ga based microwires for shape memory applications:

- **Small dimensions**
- **Easy production process**
- **Must be repeatable**
- **Adjustable T_m**
- **Monocrystalline structure helps**
- **Duration over 1 000 000 cycles**
- **100µm can lift up to 800g**
- **Smart actuators**



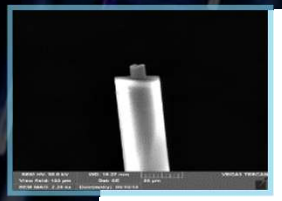
FUTURE



Artificial SMART muscles

Can sense its actuation through the permeability or Impedance sensing => Very precise control of motion

Contactless pump/syringe (in-vivo?)




RVmagnetics
Thank you for your attention
When size matters
Development of miniaturized smart sensors