Ni2FeGa Microwires for Actuator

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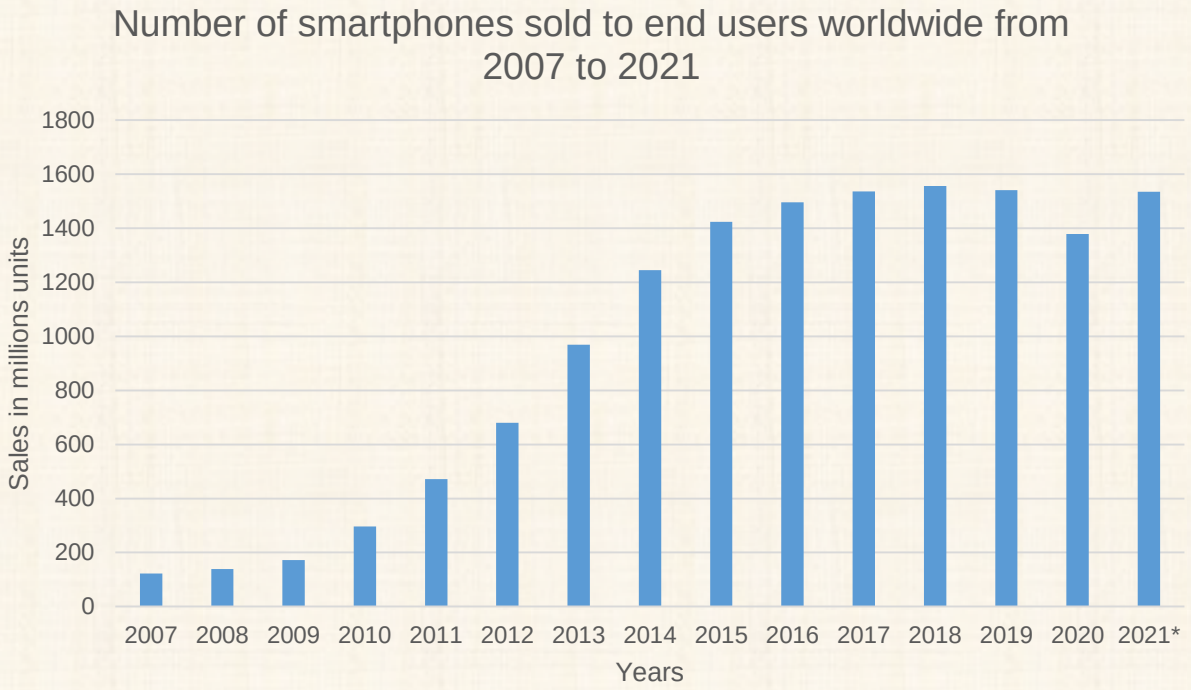
Kosice, 16th June 2021

Motivation



Increases electronic demands

NCES. (n.d.). Number of smartphones sold to end users worldwide from 2007 to 2021. In Statista - The Statistics Portal. Retrieved June 09, 2021, from https://www.statista.com/statistics/263437/global-smartphone-sales-to-end-users-since-2007/.

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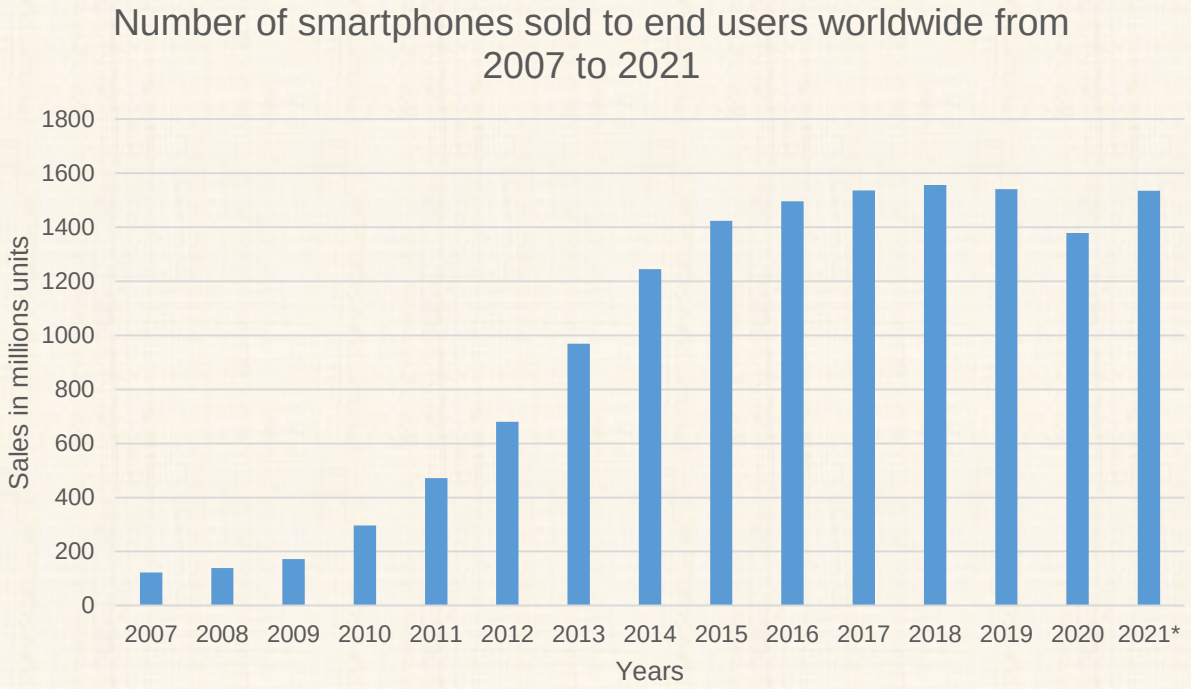
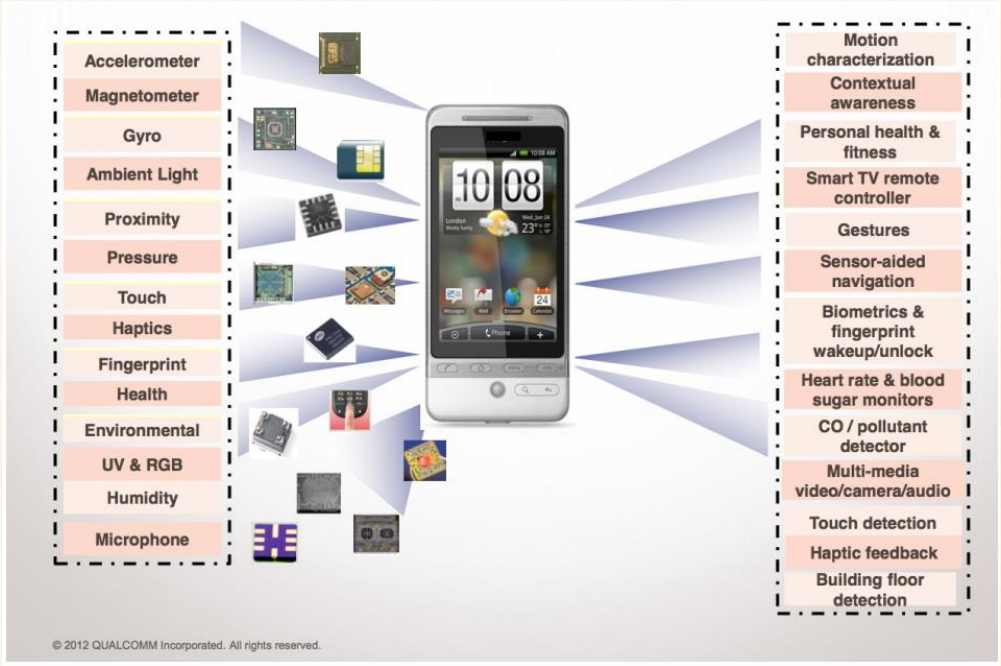


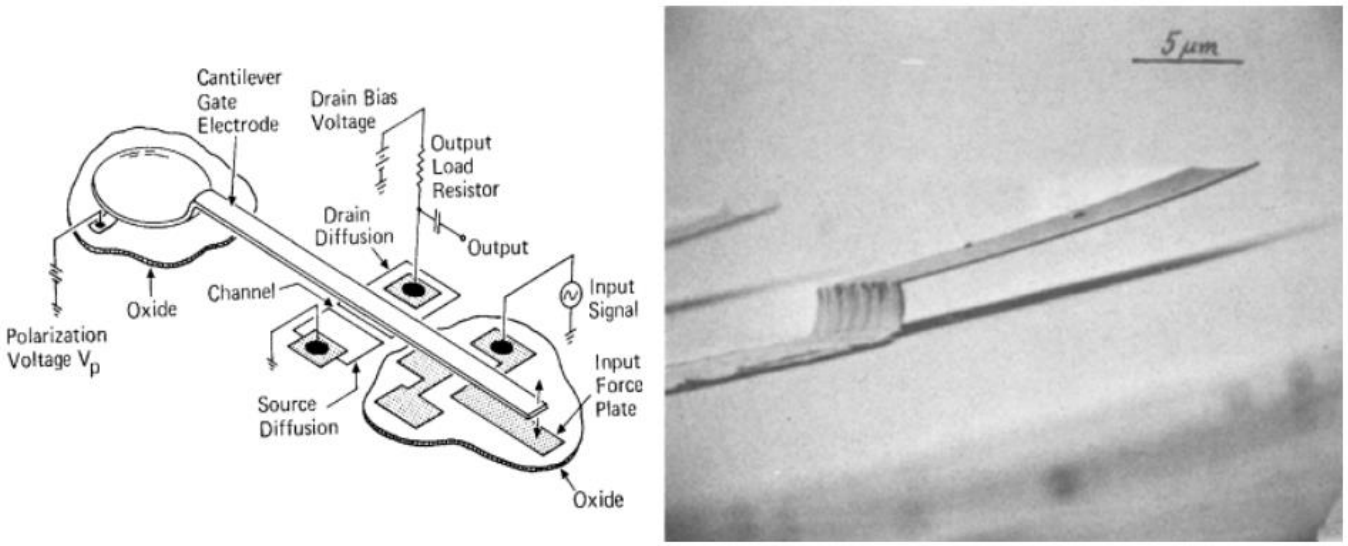


Increases electronic demands → Increases MEMS (micro-electro-mechanical-systems)demands

NCES. (n.d.). Number of smartphones sold to end users worldwide from 2007 to 2021. In Statista - The Statistics Portal. Retrieved June 09, 2021, from https://www.statista.com/statistics/263437/global-smartphone-sales-to-end-users-since-2007/.

Motivation

Micro Actuator



The resonant gate transistor reported by Nathanson et. al. in 1964 and the polysilicone cantilever reported by Howe and Muller in 1993

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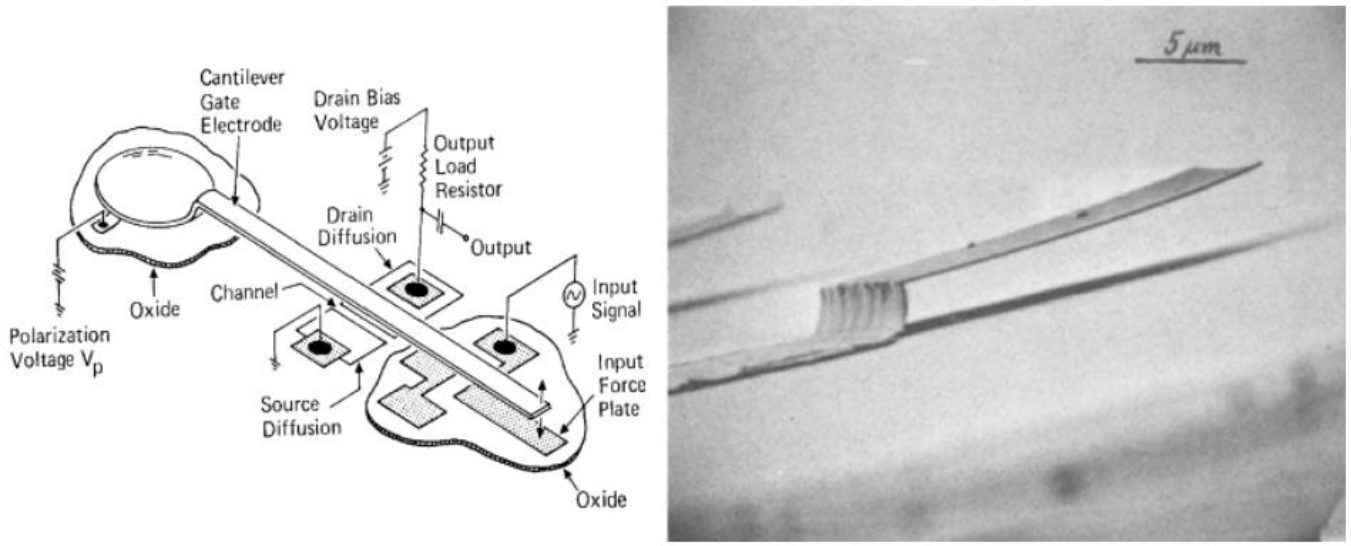
Motivation

Micro Actuator



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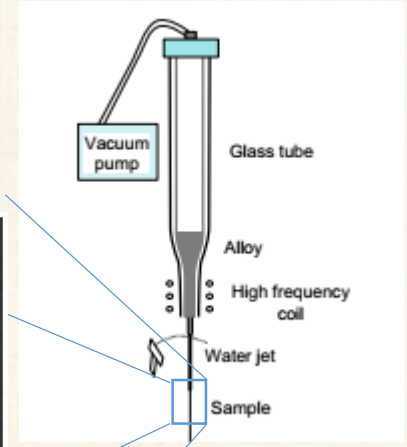
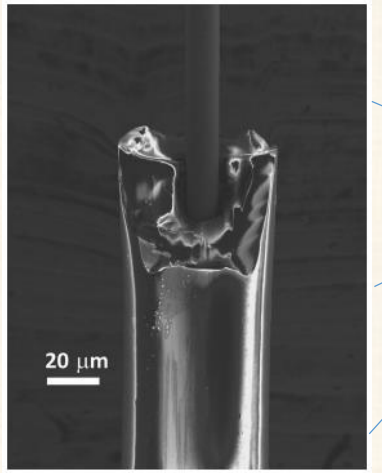
Taylor-Ulitovsky Method





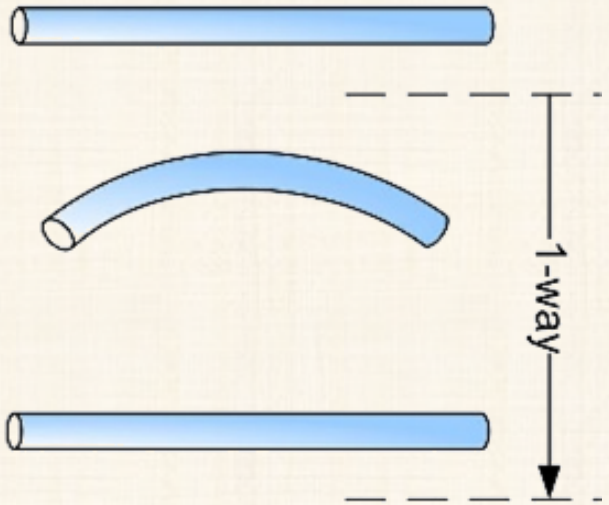
Microwire with shape memory effect

-FAST
-BIOCOMPATIBLE
-DURABLE

R. Jurc, et. Al., 28 - Sensoric application of glass-coated magnetic microwires,, Editor(s): Manuel Vázquez,, In Woodhead Publishing Series in Electronic and Optical Materials,, Magnetic Nano- and Microwires (Second Edition),, Woodhead Publishing,, 2020,, Pages 833-868, , ISBN 9780081028322,, https://doi.org/10.1016/B978-0-08-102832-2.00028-1.

Shape Memory Effect and Martensitic Transformation

Material recovers to original shape by external stimuli



- heat
- magnet
- etc

Shape Memory Effect and Martensitic Transformation

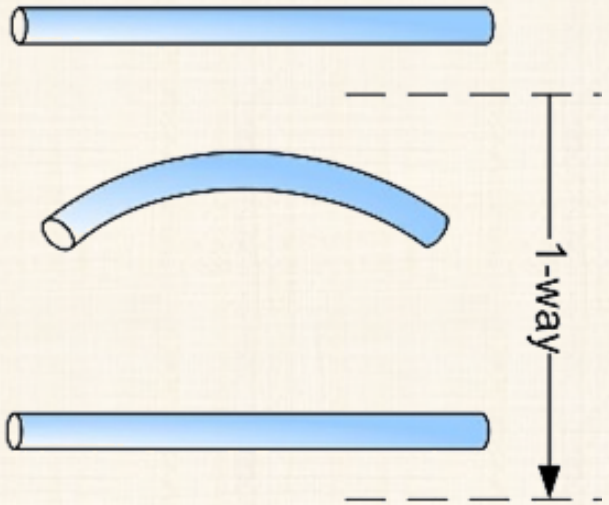
Material recovers to original shape by external stimuli

initial condition

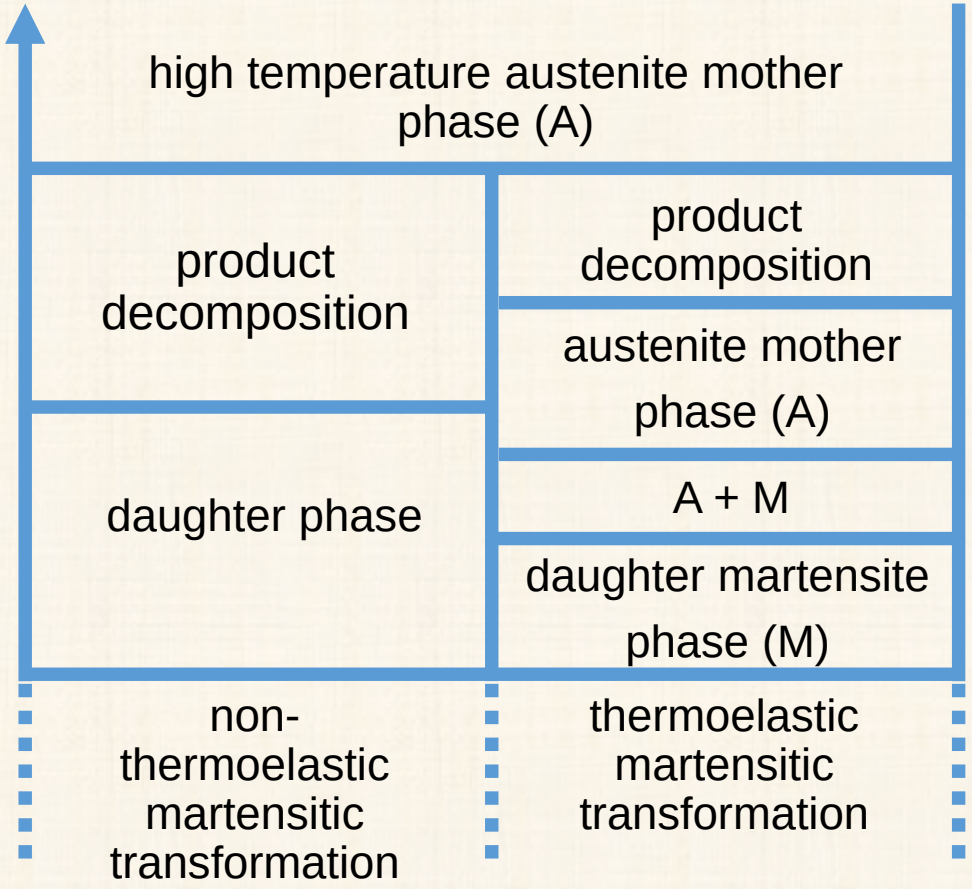
reversible deformation

External stimuli

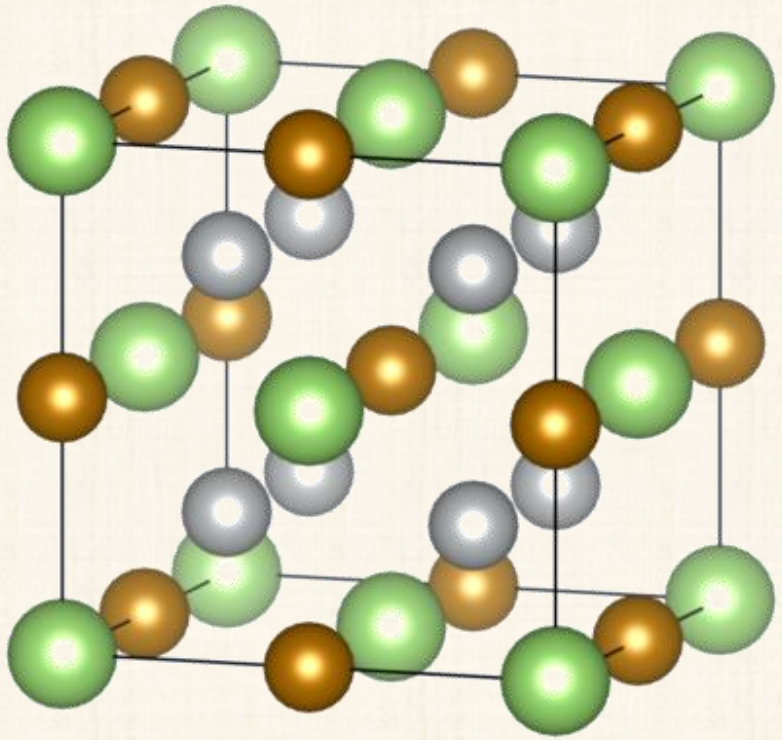
- heat
- magnet
- etc



Original shape



Ni2FeGa for Shape Memory Material



X_2YZ

Heusler Alloy

28
Ni
$[Ar]3d^8 4s^2$
nickel

26
Fe
$[Ar]3d^6 4s^2$
iron

28
Ga
$[Ar]3d^{10} 4s^2 4p^1$
gallium

Cheap

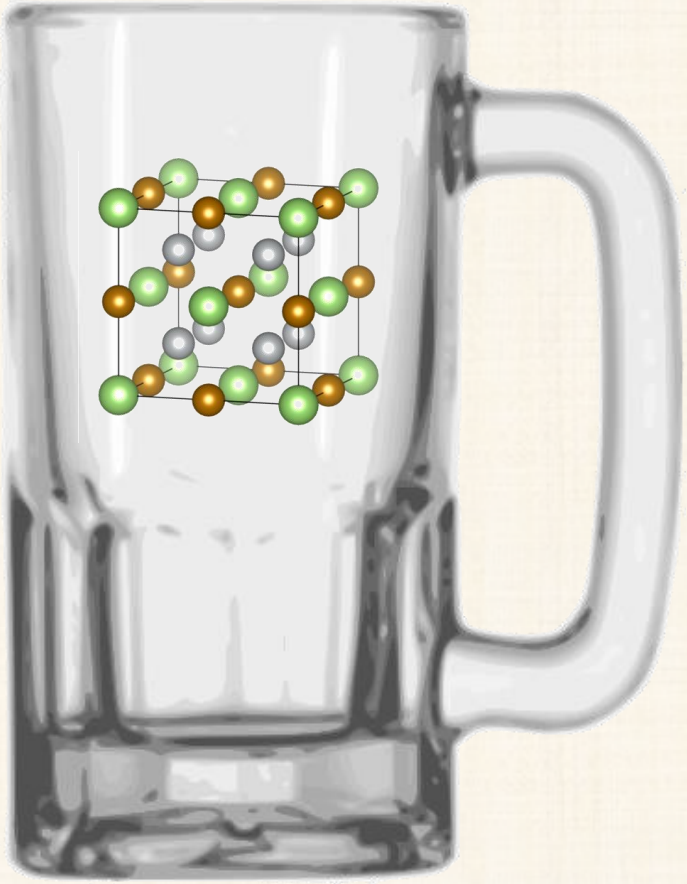
Ferromagnetic

High precision for composition

Tunable for phase transformation

Potential for sensor and actuator applications

Ni2FeGa for Shape Memory Material

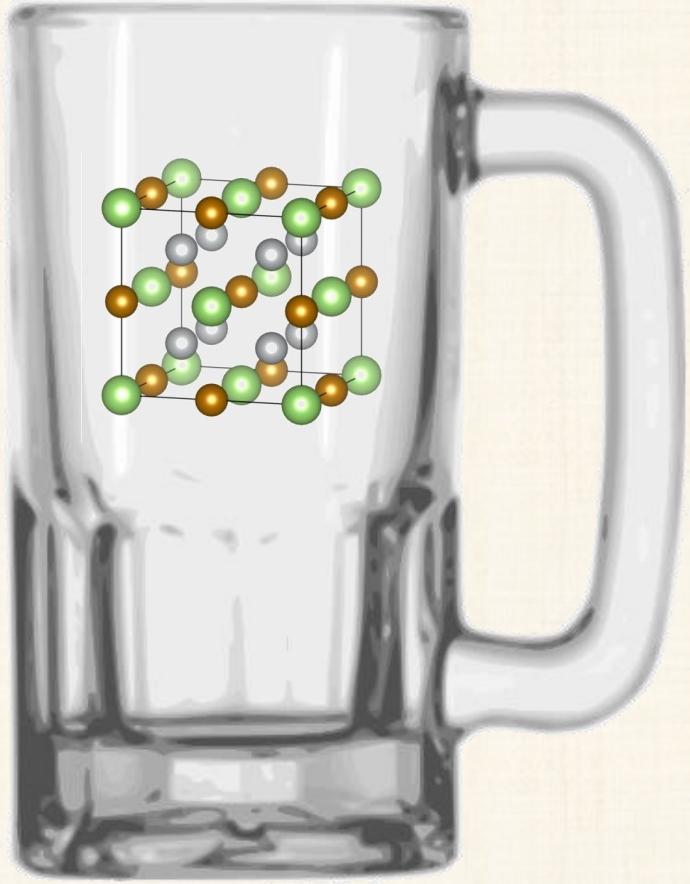


Mechanical Protection

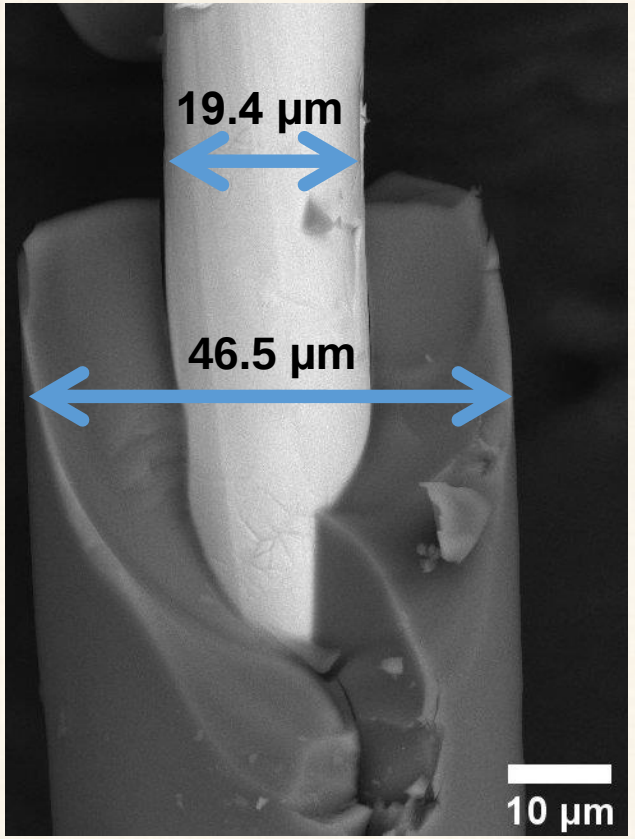
Chemical Protection

Microsize Template

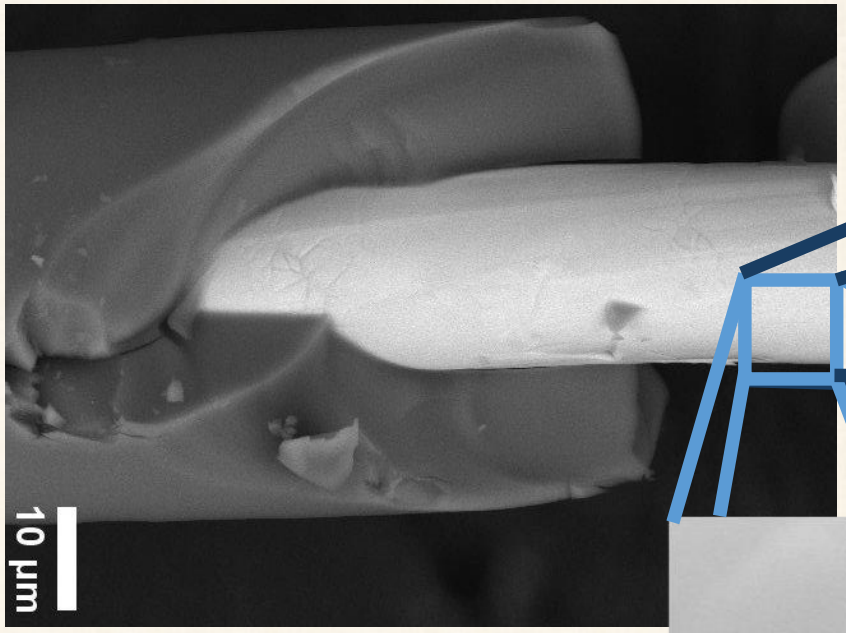
Ni2FeGa for Shape Memory Material

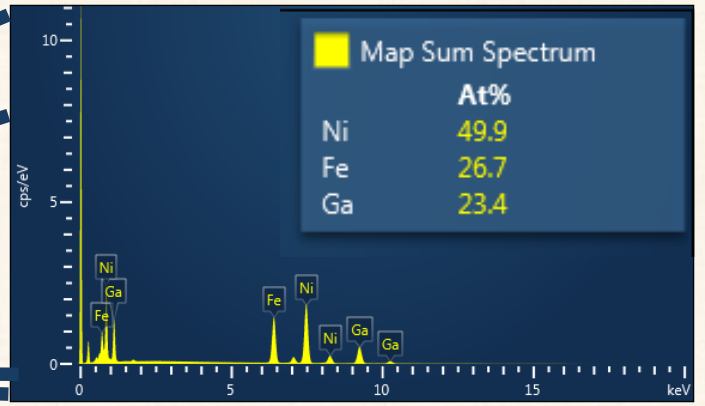


Taylor Ulitovsky Method

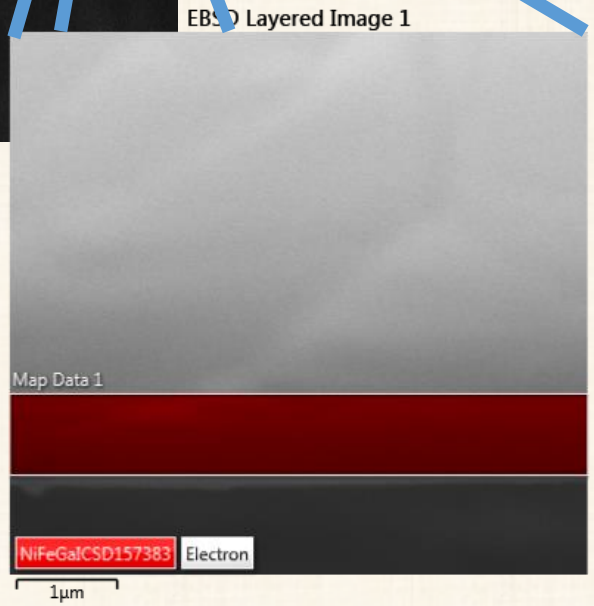


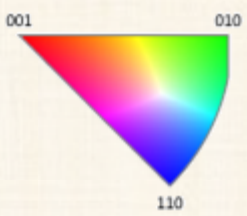
SEM + EDS + EBSD





-single wire measurement
-close to Ni50Fe27Ga23
-p. orientation -> ~ (0 1 1)

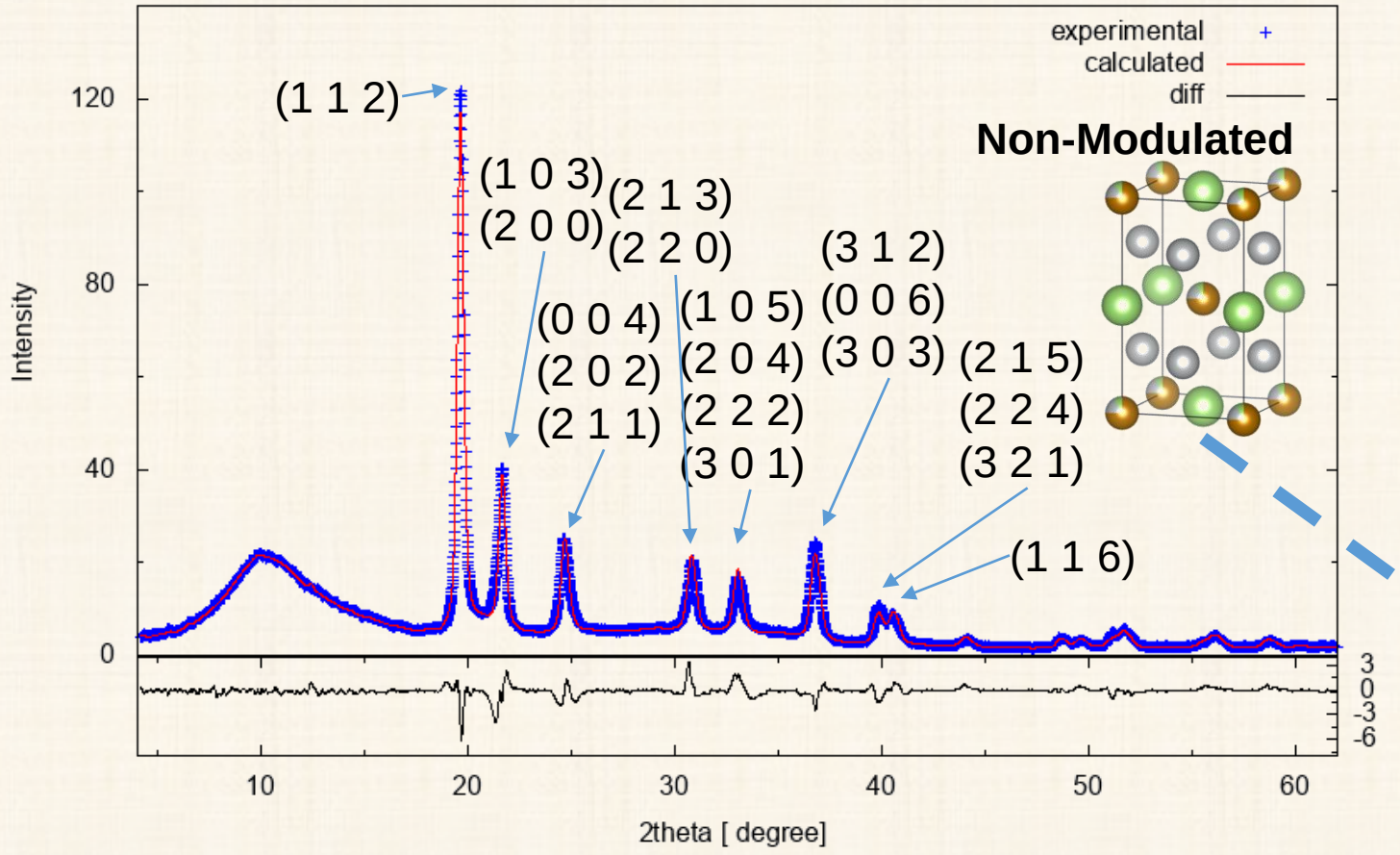




IPF

Phase Name	Phase Fraction (%)
NM	98.61
5M	0.00
A	0.00
A	0.00
Zero Solutions	1.39

XRD



high temperature austenite mother phase (A)

product decomposition

austenite mother phase (A)

A + M

daughter martensite phase (M)

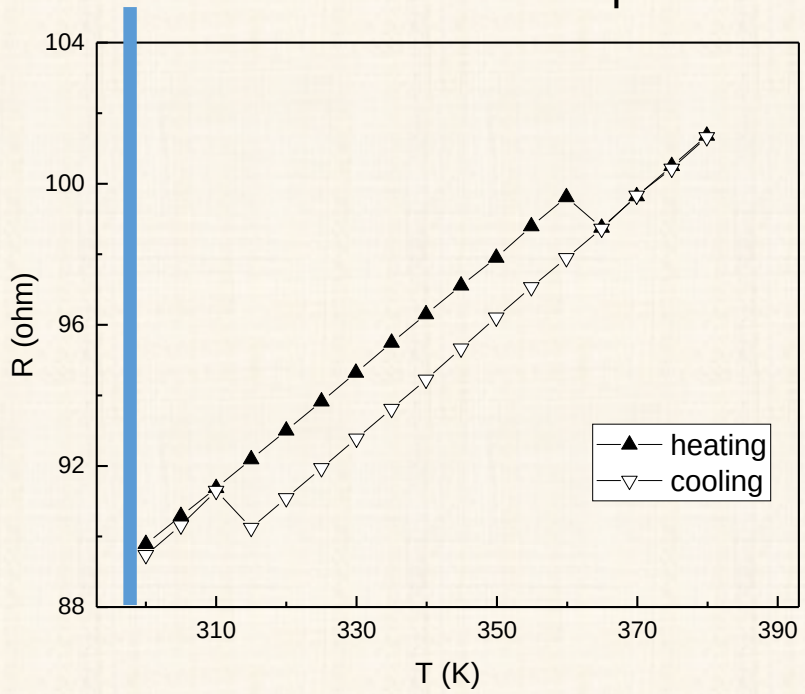
thermoelastic martensitic transformation

-a bunch of wires measurement
-the thermoelastic martensitic transformation is above room temperature

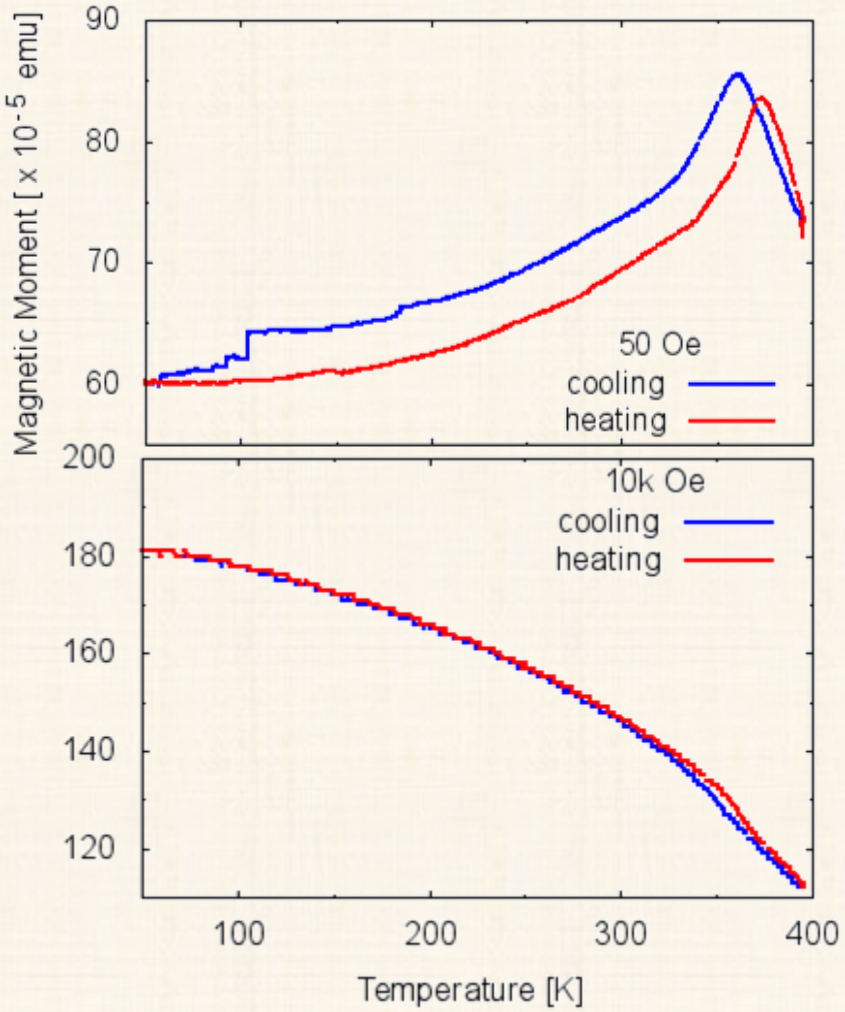
Temperature Dependence Measurements

Resistivity

XRD measurement was performed at this temperature

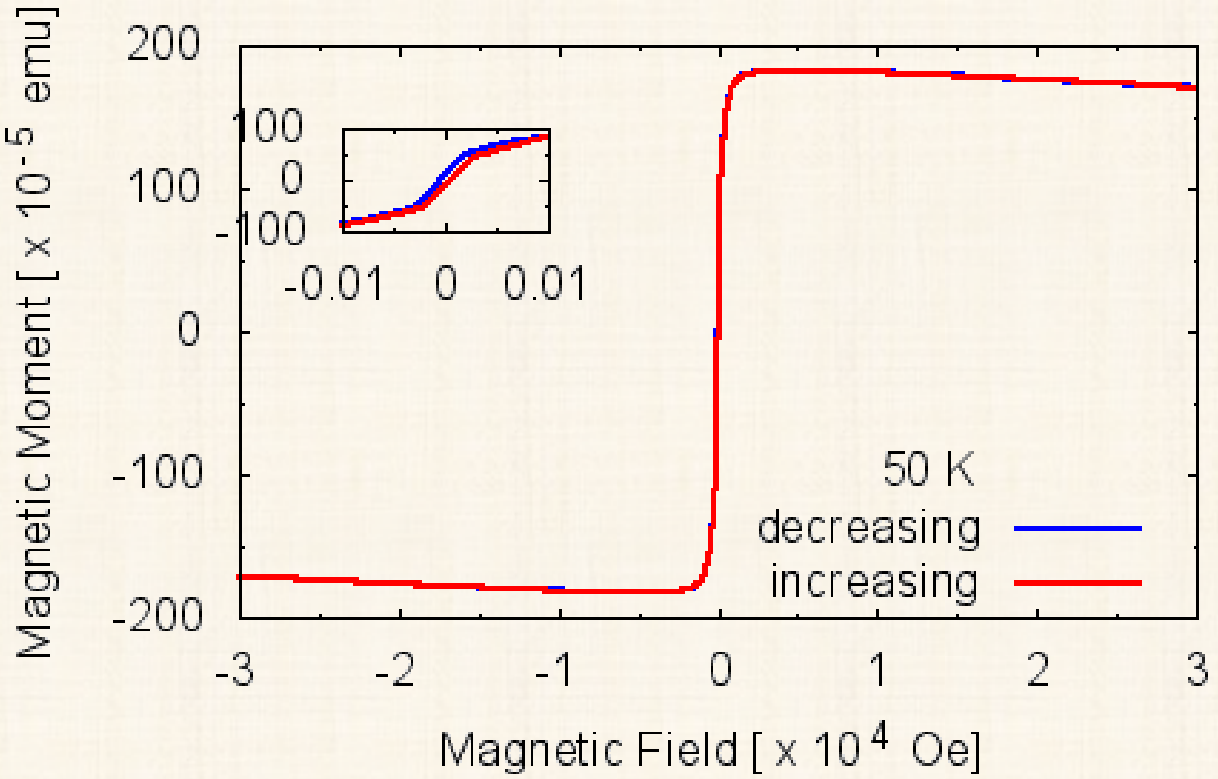


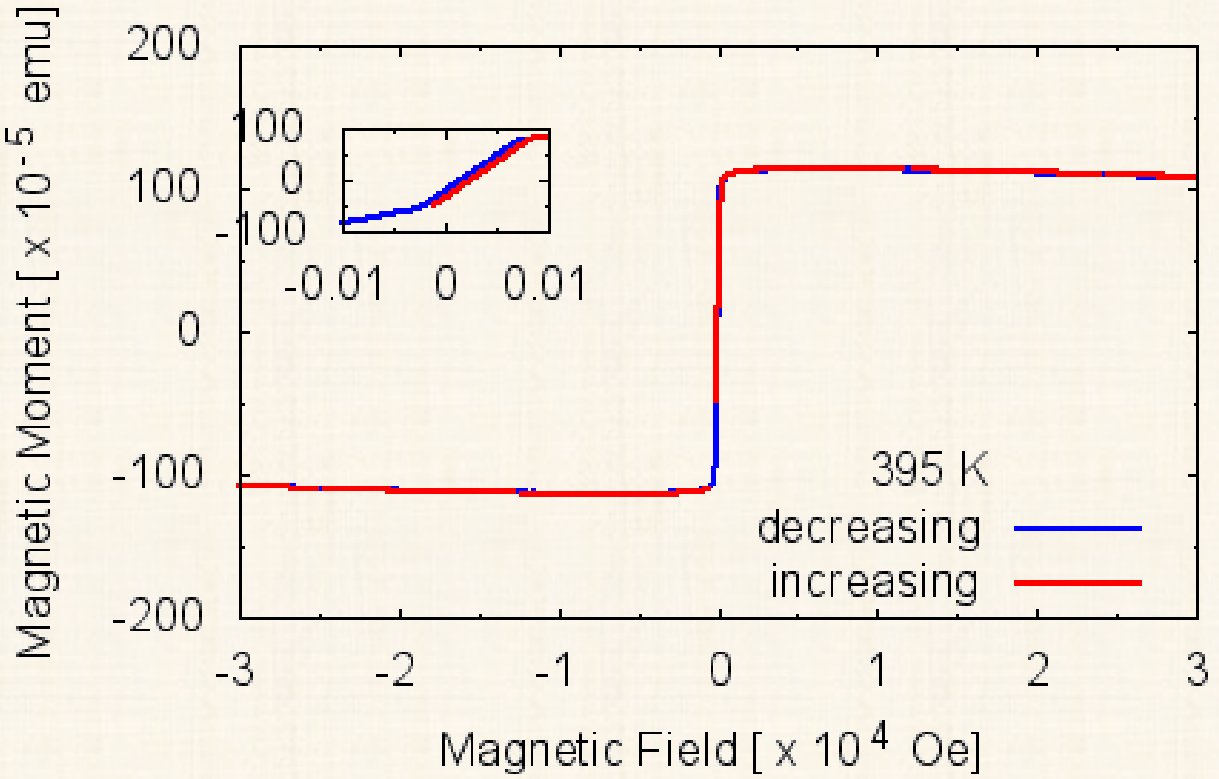
Magnetic Moment



temperature dependence measurements of resistivity and magnetic moments show that the thermoelastic martensitic phase transformation is above room temperature

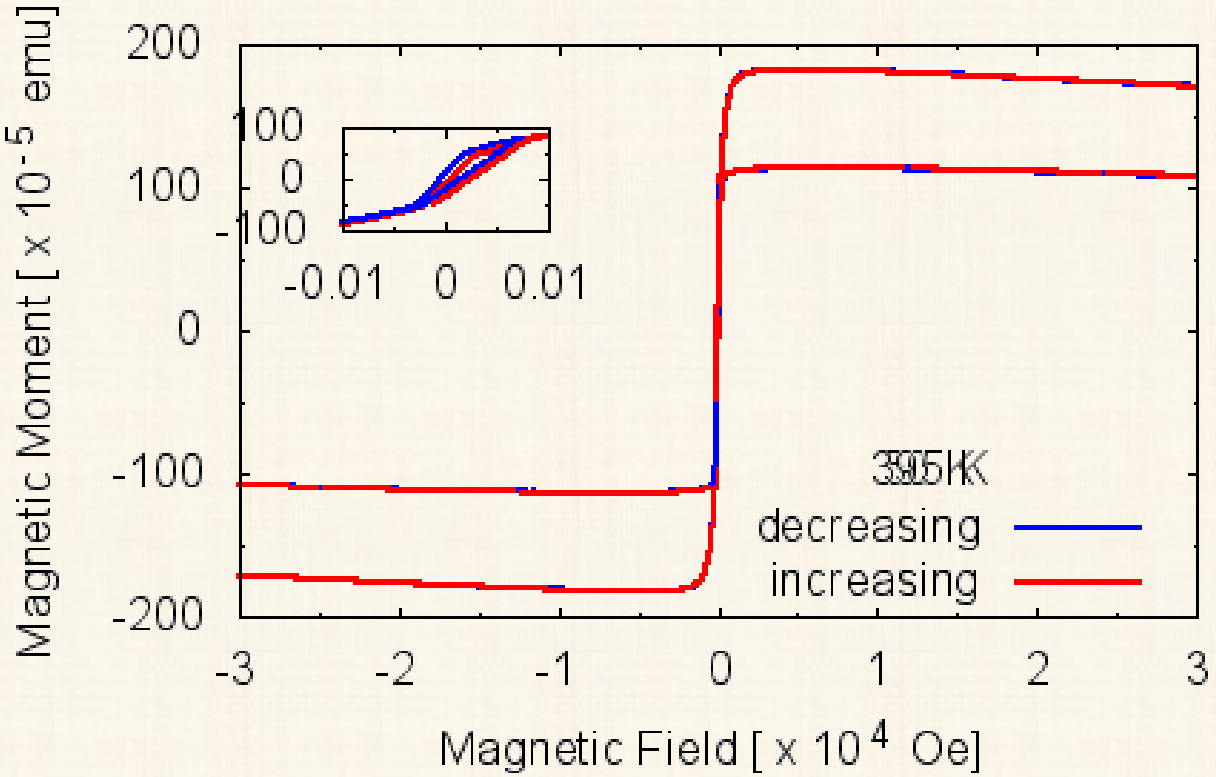
Magnetic Measurement





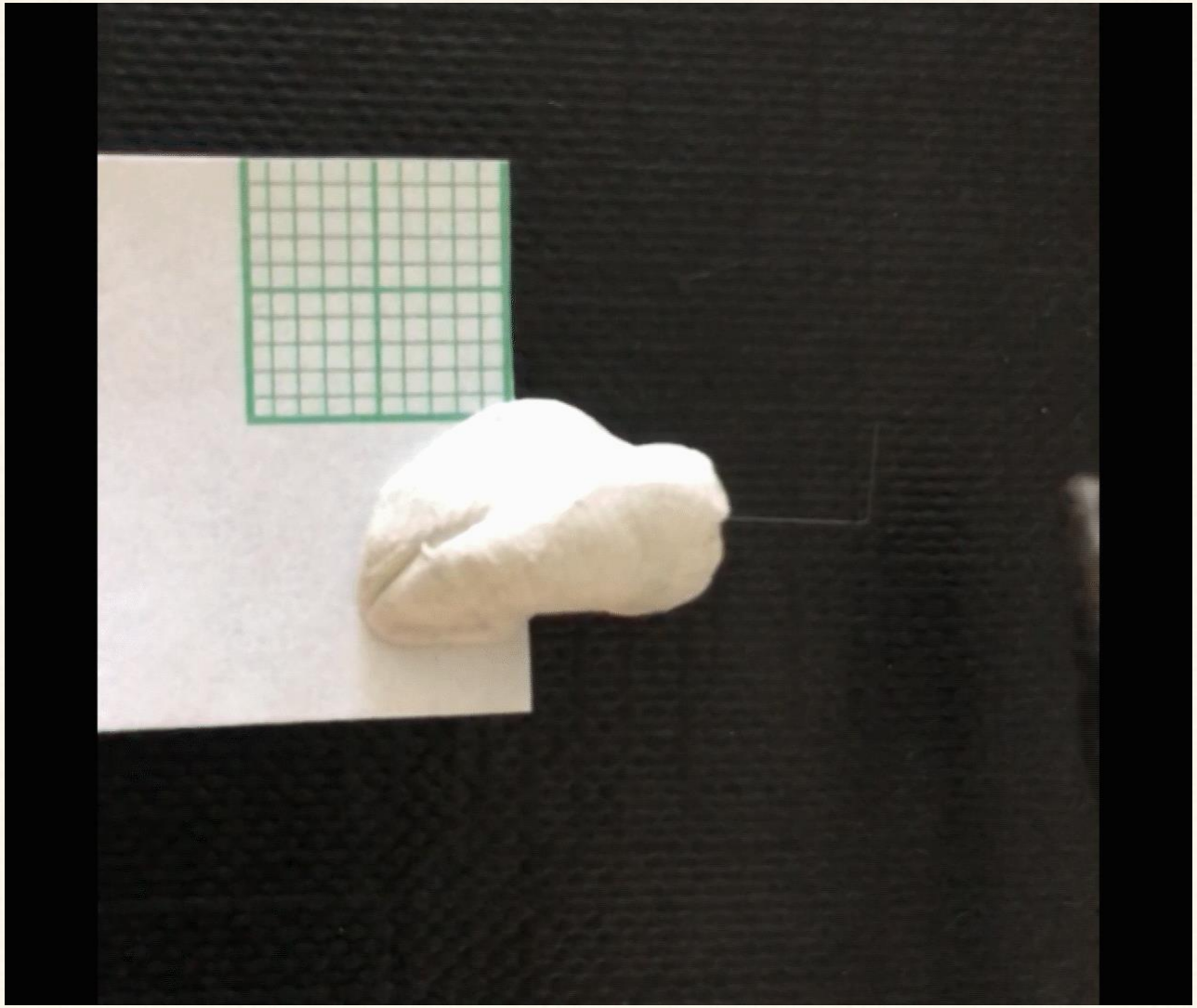
- the magnetic saturation is higher at low temperature than at high temperature

Magnetic Measurement



- the magnetic saturation at low temperature is higher than at high temperature
- the magnetic permeability at low temperature is almost similar in the microwire, the easy axis of martensitic daughter phase and austenite parent phase are toward the same direction.

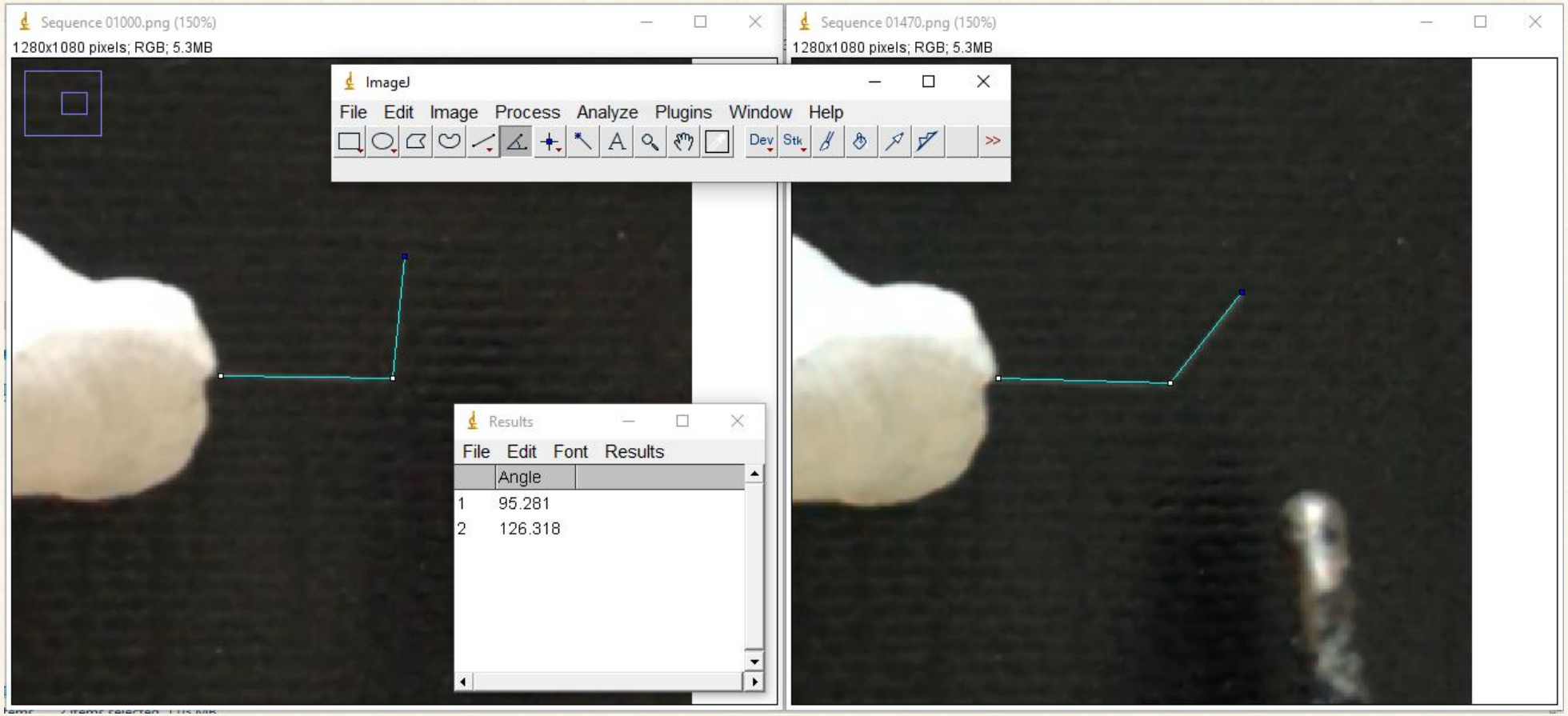
Shape Memory Effect



Shape Memory Effect

Deformed shape

Original shape



Conclusions

- Shape memory Ni2FeGa microwire has been successfully fabricated by Taylor Ulitovsky method.
- Room temperature back scattered electron diffraction and x-ray diffraction shows the presence of non-modulated martensite phase.
- The forward and backward of thermoelastic martensitic transformation happen above room temperature that can be utilized for actuator application.
- The shape memory effect of the microwire effect has been demonstrated.

Future Works

- Developing setup for measuring the resistivity and angle measurement simultaniously
- Varying the Fe:Ga ratio
- Temperature dependence x-ray diffraction in ESRF
- Magnetic field dependence of thermoelastic martensitic transformation

Thank you for your attention