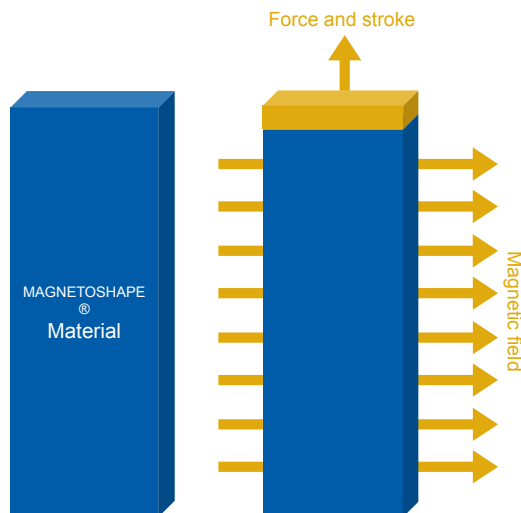


MAGNSHAPE
Magnetic shape memory technology

Magnetic shape memory technology explained briefly



Magnetic shape memory alloys are ferromagnetic materials that generate force and motion under moderate magnetic fields. The typically single crystalline alloys made from nickel, manganese and gallium are able to generate 6% strain under external loads. And they do this with frequencies into the low kilohertz range.

The magnetic shape memory effect was discovered in the mid-1990s. Over the past few years, ETO has been carrying out intensive research in the area of the magnetic shape memory effect, significantly developing the material further and constructing actuators based on this. Today, ETO's new MAGNETOSHAPE® is ready for use in initial series applications. Thanks to its unique advantages, the technology has the potential to replace electromagnetic and other actuator technologies in future.

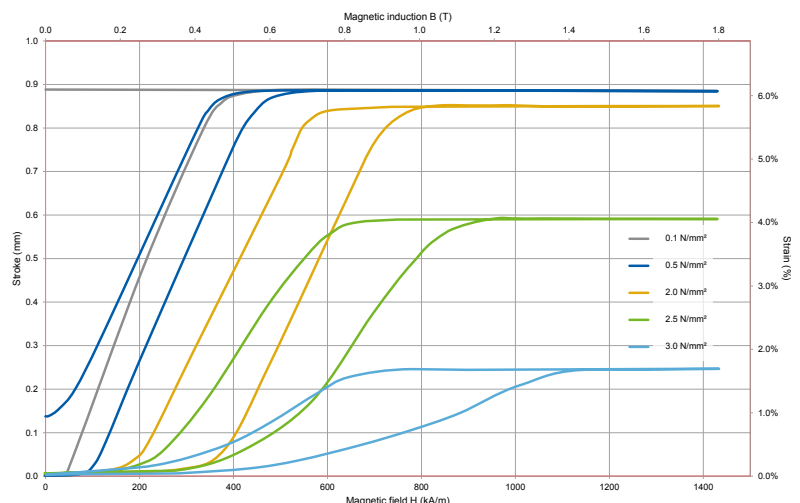
Manufacture of single crystal MAGNETOSHAPE® material



- The raw materials are melted and alloyed inductively at around 1,400 °C
- Large single crystals are drawn using a modified Bridgman process
- The crystals are heat-treated for chemical homogenisation and adjustment of the microstructure
- The crystal orientation is determined using X-ray diffraction
- The crystals are typically cut into cuboid elements
- The elements are configured for the application

Technical data of the MAGNETOSHAPE® material

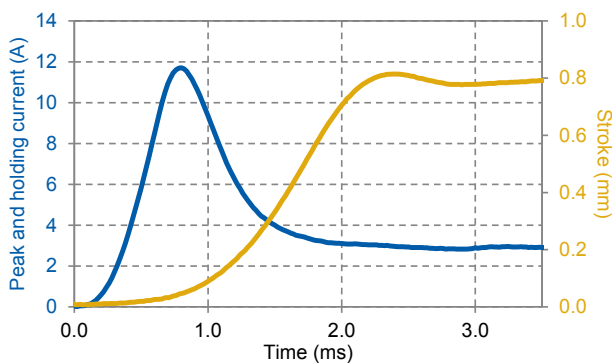
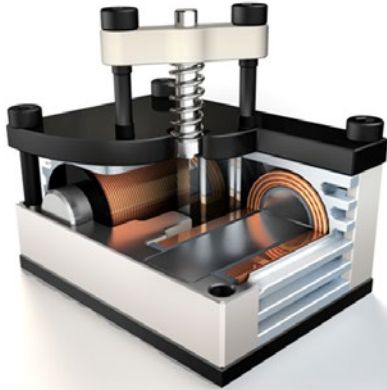
MAGNETOSHAPE®	
Alloy	NiMnGa
Field induced strain	6% under up to 2 N/mm ²
Blocking stress	Up to 3.5 N/mm ²
Switching field	0.6 T
Temperature limits	-40 °C - 60 °C
High cycle fatigue	2x10 ⁹ (material)
Typical element size	1 x 3 x 10 mm ³ to 6 x 6 x 30 mm ³
Magnetic permeability	2 (hard axis); 50 (easy axis)
Frequency	DC to 1 kHz
Switching speed	<1 ms (depending on actuator)



The design principles of the MAGNETOSHAPE® actuators

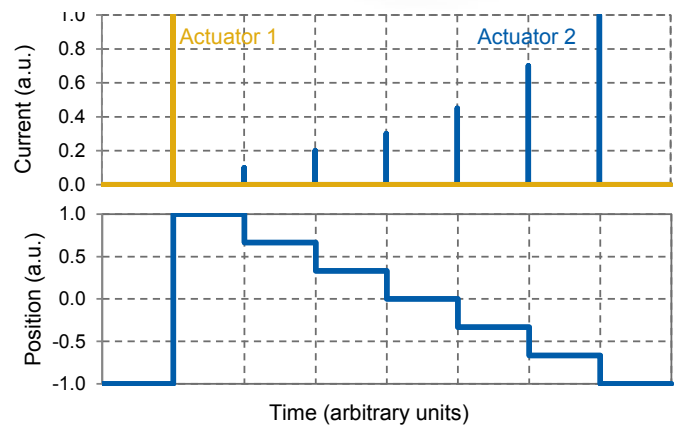
MAGNETOSHAPE® spring actuator

- Return springs opposite the MAGNETOSHAPE® element
- Extremely short switching times (~ 1 ms)
- Bistable variant with permanent magnet possible
- Different magnetic circuits dependent on the functionality needed (force, displacement, frequency)



MAGNETOSHAPE® push-push actuator

- Two MAGNETOSHAPE® actuator units work antagonistically
- Energy-efficient multi-stability
- Intermediate positions are stable without power consumption
- Enables fast and precise position control (< 5 μm)



Benefits of MAGNETOSHAPE® actuators

- Energy-efficient
- Offer a high work output at high frequencies
- Enable improved design of the actuator with low tribological wear
- Display extremely fast switching characteristics
- Allow for high service life applications
- Can be designed as bistable or multistable actuators as well as monostable actuators with fail-safe functionality
- Can be thermally activated simultaneously
- Offer self-sensing ability

Non-actuator applications

MAGNETOSHAPE® smart materials can also be used for non-actuator applications. This is enabled by the inverse magnetic and thermal shape memory alloy effect.

- Measurement of position, speed, force, pressure, etc.
- Energy harvesting for wireless energy supply
- Passive and active damping
- Use of specific alloys as high-temperature shape memory alloys (SMA)
- Thinned monocrystalline material (< 30 μm) for microsystem-based applications (actuator, sensor, harvesting)
- Thin-film materials are in development in academia



Contact us with questions on the MAGNETOSHAPE® technology and MAGNETOSHAPE® based project proposals on:

magnetoshape@etogruppe.com

ETO MAGNETIC GmbH

Hardtring 8
78333 Stockach
GERMANY
Telephone: +49 7771 809-0
Email: EST@etogruppe.com

ETO MAGNETIC CORP.

5925 Patterson Ave S.E.
Grand Rapids, MI 49512
USA
Telephone: +1 616 9572570
Email: EGR@etogruppe.com

EKS Elektromagnetik GmbH

Steinbeisstraße 50
71665 Vaihingen/Enz
GERMANY
Telephone: +49 7042 107-0
Email: EKS@etogruppe.com

**ETO MAGNETIC TECHNOLOGIES
(Kunshan) Co., Ltd.**

Guzheng Road 8
215334 Kunshan
CHINA
Telephone: +86 512 57909000
Email: EKC@etogruppe.com

ETO SENSORIC GmbH

Löffelholzstraße 20
90441 Nuremberg
GERMANY
Telephone: +49 911 41891-0
Email: ESN@etogruppe.com

ETO MAGNETIC India Pvt. Ltd.

No.278, Ground Floor, 13A cross,
15th Main, F Block, Behind SBI Bank,
Sahakaranagar,
Bangalore - 560092, Karnataka
INDIA
Telephone: +91 80 48522955
Email: EBI@etogruppe.com

ETO MAGNETIC Sp. z o.o.

ul. Eugeniusza Kwiatkowskiego 7
52-407 Wrocław
POLAND
Telephone: +48 71 38843-00
Email: EWR@etogruppe.com

**ETO MAGNETIC Mexico,
S. de R.L. de C.V.**

Av. Interpuerto No. 675
Col. Parque Logístico
78395 San Luis Potosí, S.L.P.
MEXICO
Telephone: +52 444 47879-00
Email: ESM@etogruppe.com