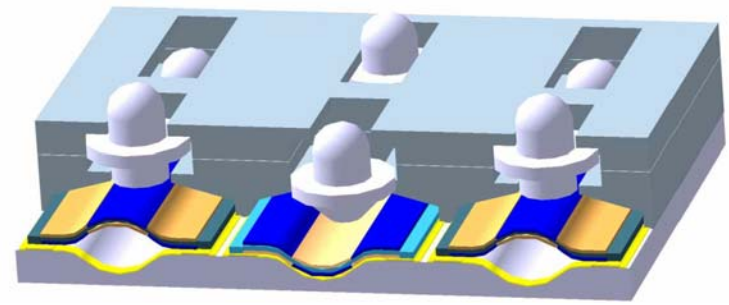
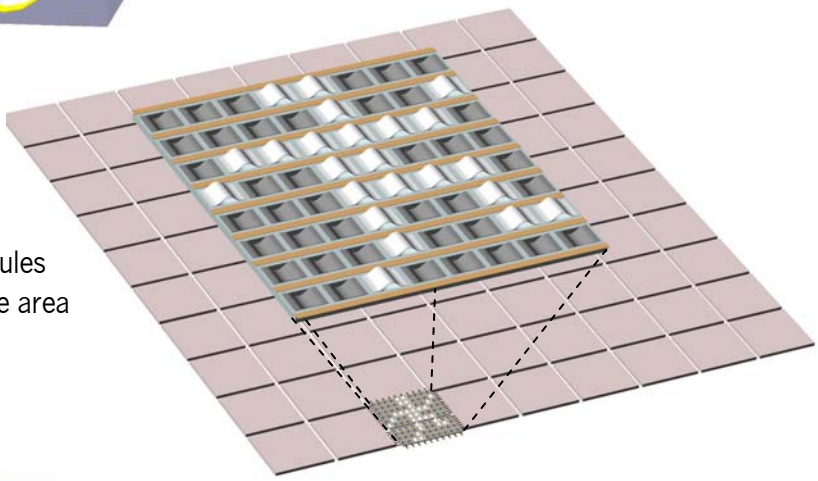
A New Approach to Tactile Graphical Displays Based on Shape Memory Alloy Microactuators
I. Design

The research center caesar is currently working on a project which integrates thin film shape memory alloys (SMAs) into tactile modules. The project proposes flat tactile displays suitable for graphical information and mobile communication. The technology provides

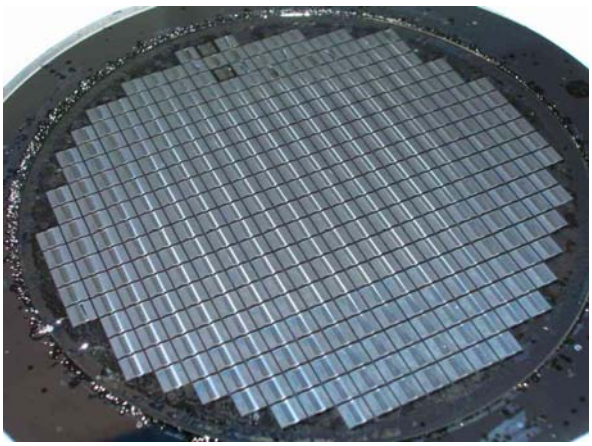


- Compact design by thin film technology
- Low voltage power supply
- Modularity and
- Compatibility to Batch Processing.



Designed in Modules

The thin film displays can be realized in modules allowing for their arrangement to create large area displays. The illustration the right depicts an actuator array with 8 x 8 SMA actuators.

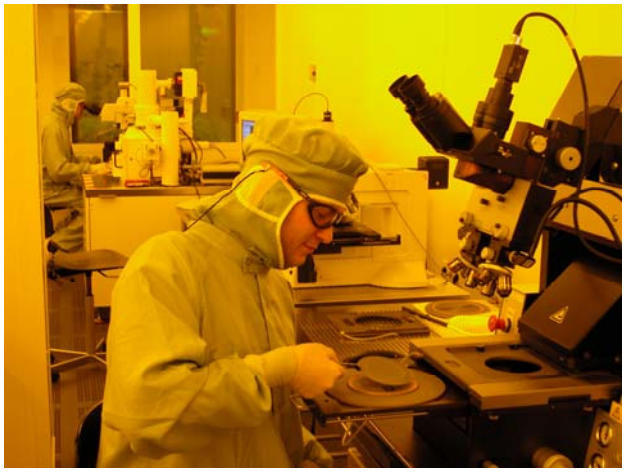


Parallel Processing

The displays can be produced parallel in a batch process without complex assembling procedures in a cost effective way.
The photo on the left shows a 4”-Wafer with a wave-like formed surface and structured metallic composites made by lithographic processing steps.
The metallic actuators are partly detached by sacrifical layer teqniques.

Development at caesar

The project is being carried out by the Microrobotics department of the research center caesar in Bonn, Germany. The center contains cleanroom facilities with state of the art technology in microsystem fabrication. The staff is highly experienced in shape memory thin film deposition.



The concept was awarded a prize by the foundation ONCE, Spain in 2004.

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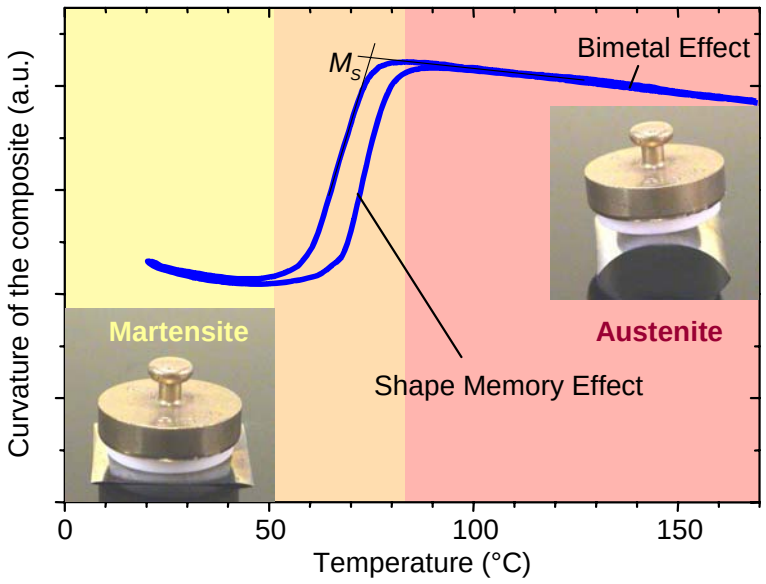
II. Technical Aspects

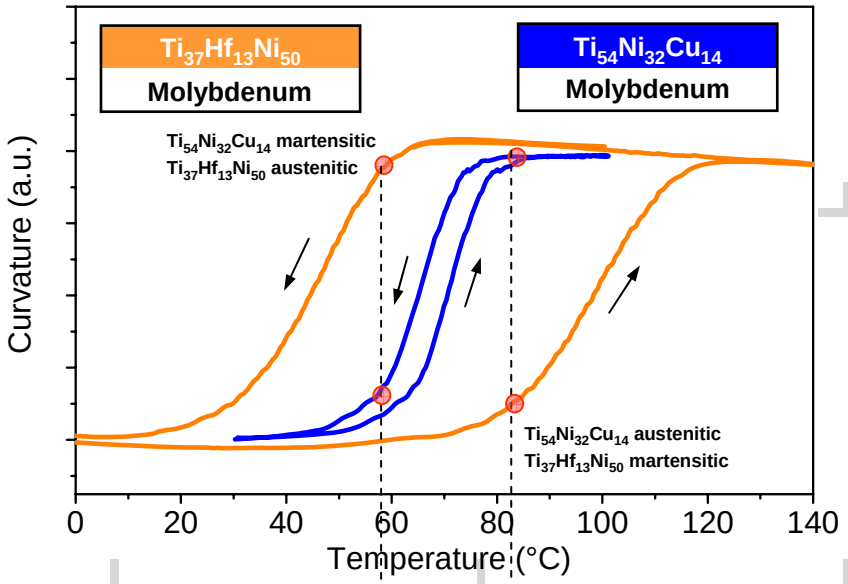


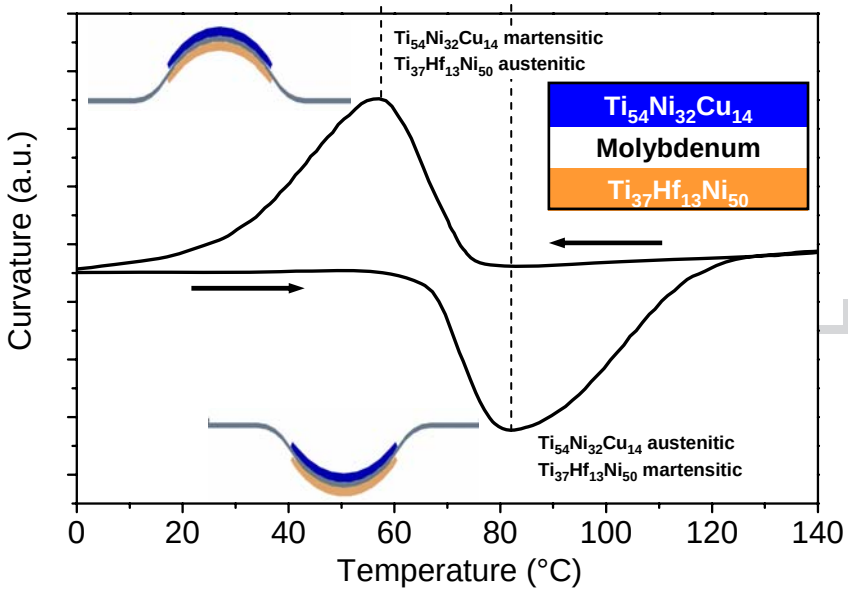
Mechanism of Thin Film SMAs

SMAs change their elastic properties significantly upon the martensitic transformation. Thus the curvature of bimorph SMA composites can be switched within 20 K providing 10 times the work output of conventional bimetals (Fig. left).
The work output of SMA composites is also 50 times higher than that of piezoelectric actuators used in commercial Braille cells.
The thin film NiTiX/Mo (X = Cu, Hf) composites show the hysteretic two-way behavior right after deposition and annealing treatment without the necessity of further training, which is compatible to parallel processing.

Mechanism for Bistability

In the particular case of the composites $Ti_{54}Ni_{32}Cu_{14}$/Mo and $Ti_{37}Hf_{13}Ni_{50}$/Mo, the hysteresis of the curvature vs. temperature curves are nested (Fig. right). As a consequence, upon heating at 83°C, $Ti_{54}Ni_{32}Cu_{14}$ is austenitic while $Ti_{37}Hf_{13}Ni_{50}$ is martensitic. At 58°C upon cooling from 120°C the situation is vice versa: $Ti_{37}Hf_{13}Ni_{50}$ is austenitic while $Ti_{54}Ni_{32}Cu_{14}$ is martensitic.
Considering the case of the composite $Ti_{54}Ni_{32}Cu_{14}$/Mo/$Ti_{37}Hf_{13}Ni_{50}$ (Fig. below), the actuator can be bent in opposite directions depending on the temperature cycle carried out. If the Mo foil is pre-bulged so that there are two stable positions of the foil, the curvature can be switched between concave and convexe and vice versa just by applying appropriate heat pulses. After a heat pulse to at least 120°C and subsequent cooling to room temperature, the composite will end up bent upwards. On the contrary, the actuator is bent downwards after a heat pulse to 83°C.
By means of this mechanism, microswitches can be realized providing bistable behavior, whereby energy supply is required to switch the actuator, however, whereby no energy is required to maintain the position.





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