

CSIR-NAL has made significant contributions in the area of special materials for a variety of engineering applications. Processing know-how for Ni-Ti shape memory alloys (SMAs) and a number of piezoelectric materials have been developed. A magnetoresistive sensor based on the giant magnetoresistance (GMR) (IN1221DEL2015, IN3689DEL2015) has been fabricated for the development of position sensors, and magnetometers for automotive and aerospace applications.

The surface engineering activities at CSIR-NAL have resulted in several technologies in niche areas of corrosion and tribology, energy, nanoscale architecture, etc. For example, NALSUN Solar Absorber Coating Technology has been transferred to 29 industries. Similarly, CSIR-NAL has been supplying continuously space quality mirrors to ISRO. Several of the other technologies such as: magnetic sensor, tape casting of ceramic substrates, pressure sensitive paint, eco-friendly corrosion resistant coatings and wear resistant coatings are close to commercialization.

Ni-Ti base Shape Memory Alloys

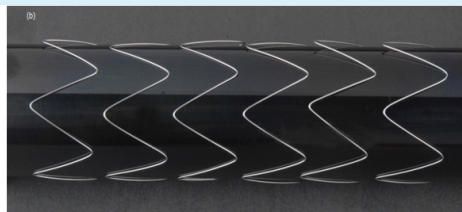
- Know-how available with CSIR-NAL for commercial production of varieties of Ni-Ti SMA products
- Products developed for both engineering and biomedical applications
- Processing know-how demonstrated in industries (HAL & MIDHANI)

Applications Aerospace	Biomedical
Shape control	Arch wires
Vibration control	Guide wires
Flow control	Stents
Safety devices	Implants

Property	NiTi (SME)	NiTi (SE)	NiTiCu (SME)
Austenite start Temp. (°C)	75-85	-10 - +10	55-75
Hysteresis (°C)	35-45	25-40	20-25
Recovery Stress (MPa) @ Af+20°C	600-700	600-700	550-600
Recovery Strain (%)	4.0-6.0	4.0-6.0	4.0-5.0
I Fatigue life (cycles) @ 2% strain & 200 MPa stress	>1,00,000	-	>1,00,000

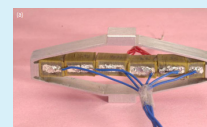


NiTi SMA products (Engineering)

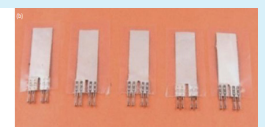


Pseudoelastic NiTi stents (Medicine)

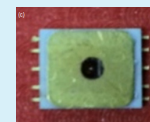
- Know-how for fabrication of varieties of piezo sensors and actuators is available with CSIR-NAL
- Multi-layer (ML) stacked sensors and actuators with high block force (5200 N)
- Piezoceramic coatings and thin films for structural health monitoring and MEMS pressure sensors
- Piezoelectric PVDF films for sensing mechanical vibration and surface pressure mapping



Amplified PZT actuator



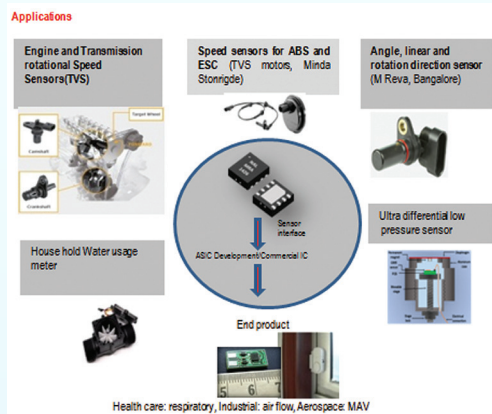
PVDF sensors



MEMS pressure sensor

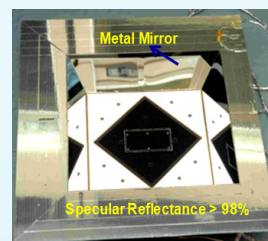
MRA Sensor for Non Contact Measurements

- Giant magnetoresistance based technology
- High sensitivity (0.08 %/G)
- 0 to ± 150 G operation range
- Omni-polar operation (either N or S pole)
- Wide gap tolerance (> 5 mm)
- DC (0 Hz) to > 1 MHz operation
- Low power consumption (2 mA @ 12 V)
- Excellent voltage and thermal stability
- Low hysteresis ($< 9\%$ FS) and nonlinearity ($< 2\%$ FS)
- Miniature size (3 mm x 3 mm)
- Low cost ($< \text{INR } 20$)



Coatings for space applications

- INSAT series of satellites use highly polished mirror panels ($R_a = 5$ nm) which act as passive radiative coolers and maintain the detector temperature of VHRR
- CSIR-NAL has successfully developed a highly polishable multilayer coating system on Al alloy panels
- Coated panels are being supplied to ISRO from the past two decades



Assembled semi-trapezoidal mirror

NALSUN Technology- Solar Energy for Water Heating

CSIR-NAL has developed cost-effective Electrodeposited Black Chrome Coating (NALSUN).

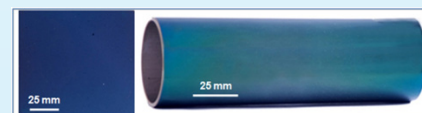
This technology has been transferred to 29 SMEs. Service life of the coating is more than 20 years & globally patented



Assembled semi-trapezoidal mirror

Spectrally Selective Coatings for Solar Thermal Power Generation Applications

CSIR-NAL has developed several sputter deposited high-temperature spectrally selective absorber coatings with $\alpha > 0.950$ and $\beta < 0.08$ for solar receiver tubes, which are found to be stable in vacuum for 1000 h at 600°C , and in air for 1000 h at 350°C under cyclic heating conditions



Absorber coating on flat and cylindrical samples

Ceramic substrates

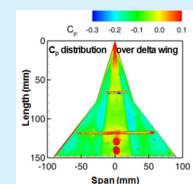
CSIR-NAL has developed tape casting process for Al_2O_3 and ZrO_2 substrates for space electronics, oxygen sensor and solid oxide fuel cell applications.

The process is also explored for the fabrication of substrates of functional materials like AlN , NiMn_2O_4 , NiO-YSZ , Sc_2O_3 stabilized zirconia, gadolonia doped ceria, glass sealant, etc.



Pressure sensitive paint

A stable binary pressure sensitive paint (NALPSP) has been formulated as an alternative to the conventionally used discrete pressure taps to map the surface pressure on wind tunnel models for transonic and supersonic flow conditions



For more information please contact:

Director, CSIR-National Aerospace Laboratories, PB 1779, HAL Airport Road, Bangalore 560 017, India.

Tel: 91-80-25086000, 25270584; email: director@nal.res.in; www.nal.res.in