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Electrical Properties and Thermal Imaging of Commercial NiTi wires

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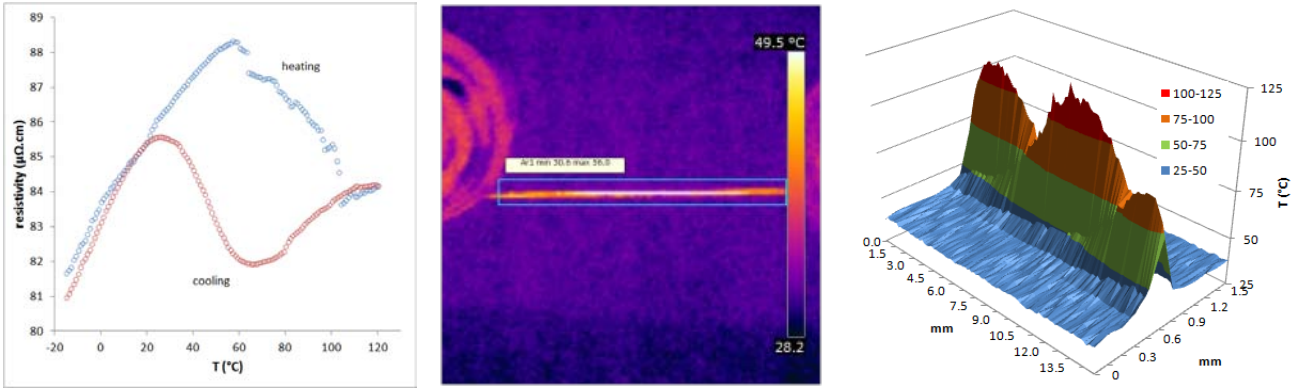
Abstract:
NiTi alloys exhibit two closely related and unique properties: shape memory effect and superelasticity. Shape memory is the ability of NiTi wires to undergo deformation at one temperature, and then recover its original, un-deformed shape upon heating above its transformation temperature. NiTi-based materials are widely accepted as one of the best families of shape memory alloys (SMA). SMA materials are sensitive to temperature and/or stress, producing a large macroscopic strain, through the so-called martensitic transformation.
Martensitic transformation is a thermoelastic reversible crystallographic phase transition from high-temperature phase (Austenite), to a low temperature phase (Martensite). In some cases (depending on alloy's composition, thermal history and manufacturing) an intermediate phase known as R-phase, appears during cooling; resulting in a two-stage process: the high-temperature Austenite phase first transforms into the intermediate R-phase and then to Martensite, at low-temperature.
The transformation behaviour has been studied by different methods, namely, electrical resistivity, differential scanning calorimetry (DSC), magnetic susceptibility, and thermoelectric power. Several studies have shown that electrical resistivity measurements can be a useful and reliable probe for the identification of both temperature and stress induced transformations. Their electrical properties reveal a potential to be used as memristive devices, thus, the exact assessment of the alloy's temperature-profile is critical.
In this work we report the resistivity measurements as well as the thermal imaging of four commercial $Ni_{1+X}Ti_{1-X}$ wires, with different composition and hence different transformation temperatures. Two of the wires were un-annealed and two annealed. Resistivity measurements were performed under constant current in a custom-made thermal bath, capable of varying the temperature in the range of -50°C to 200°C. Thermal Imaging was performed while heating the samples with constant current (up to 2A), using an i-7 FLIR thermal camera equipped with Ge close-up lenses and the whole results are presented.



(a) Typical resistivity curve (b) thermal imaging and (c) temperature profile of a NiTi wire