Punto situazione LAB1-2: design & eCAD

Corso Materiali intelligenti e Biomimetici
09/05/2019

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Esercitazione LAB3/4: SMA/QTC

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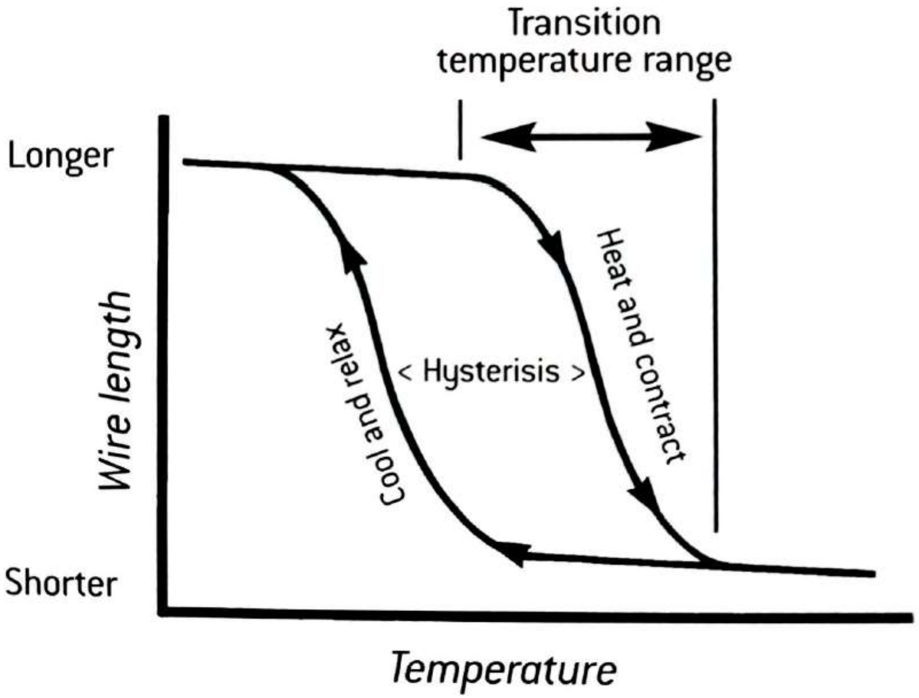
SMA wire



- **Low-temperature** -> Martensitic state (extended wire condition)
- **High-temperature** -> Austenitic state (shortened or ‘remembered’ wire condition)

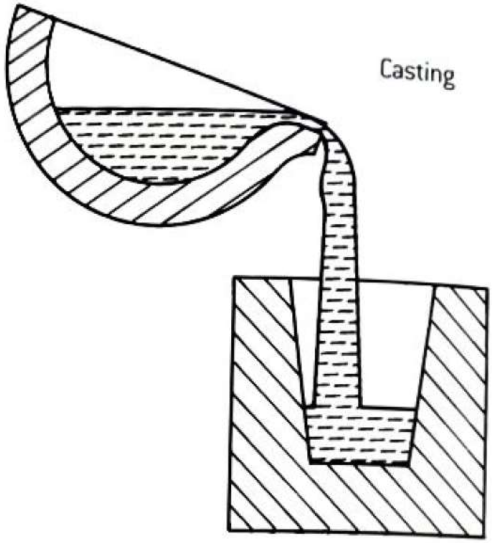
The changes of state are not immediate, but happens within a temperature range (e.g. M-state begins at 68°C and ends at 82°C) -> **hysteresis**

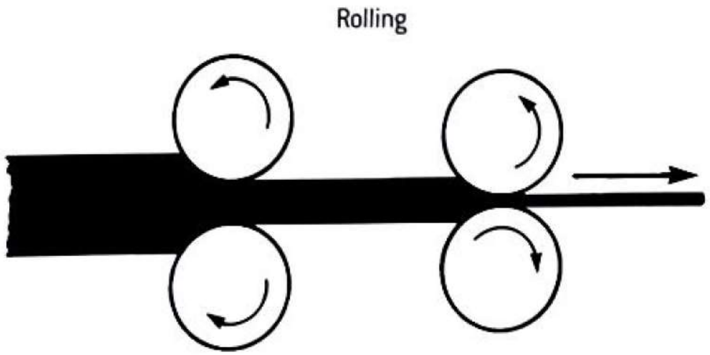
To compensate this effect, it is important that the wire is heated rapidly (e.g. large current)

Nitinol

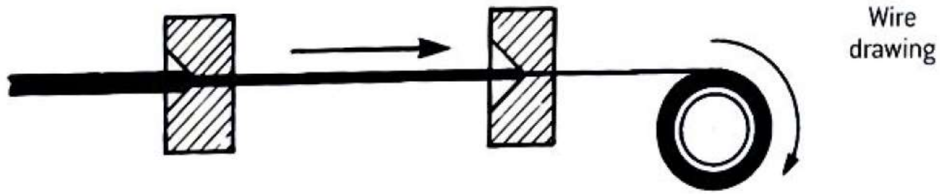
Stages in manufacturing

- Equal amounts of nickel and titanium are combined and melted in an electric furnace at 1300°C. The process is carried out in a vacuum and any contamination by other material is strictly avoided. The melt is then cast into small ingots.





- The ingots are rolled into rod, bar or sheet form. If wire is required, the bar stock is further drawn down to diameter through very hard dies of decreasing diameter.



- Finally, the wire is given its memory by carefully controlled heat treatment and 'conditioning'. This process is carried out continuously.

Example of SMA Wire Data

d = 100 um
l = 10 cm

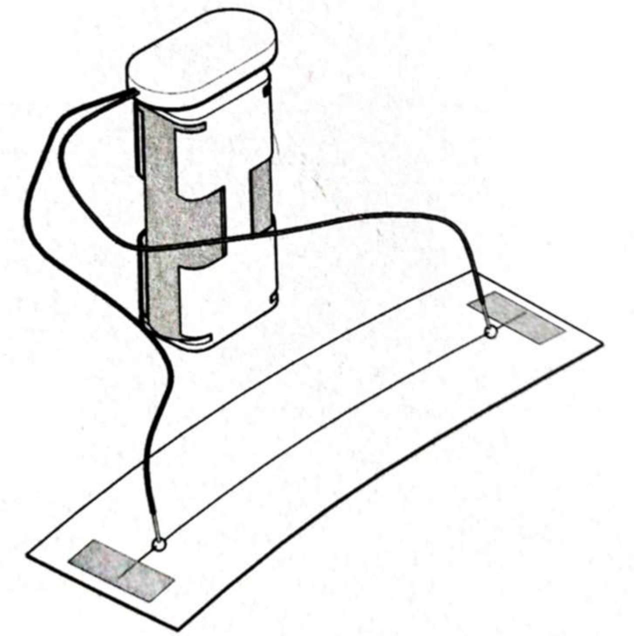
Melting point: 1300ºC

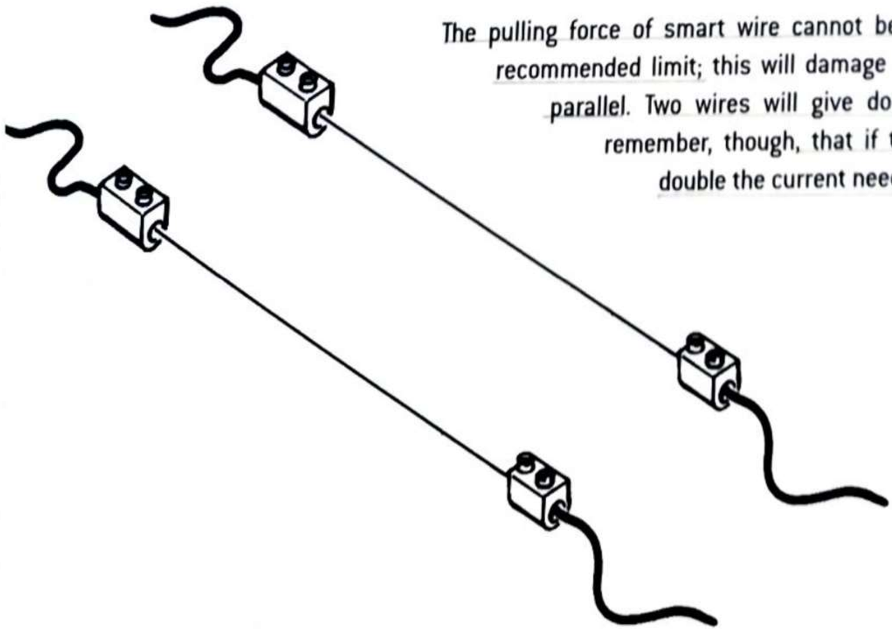
Ultimate Tensile Strength (UTS): 1100 MN/m2

[Note: will undergo deformation of 15%-30% before failure]

Bias force	0.3 N
Pulling force	1.5 N
Resistance	150 ohms per metre
Max. current	180 milliamps
Max. power	5 Watts per metre
Shortening time	0.1 second
Relaxation time	1.0 second
Recommended extension	5%
Minimum bend radius	5 mm
Effective transition temperature	70º Centigrade
Pulling starts at	68ºC
Pulling finishes at	78ºC
Relaxation starts at	52ºC
Relaxation finishes at	42ºC

Esercitazione SMA (LAB3)





Increasing the pulling force of smart wire

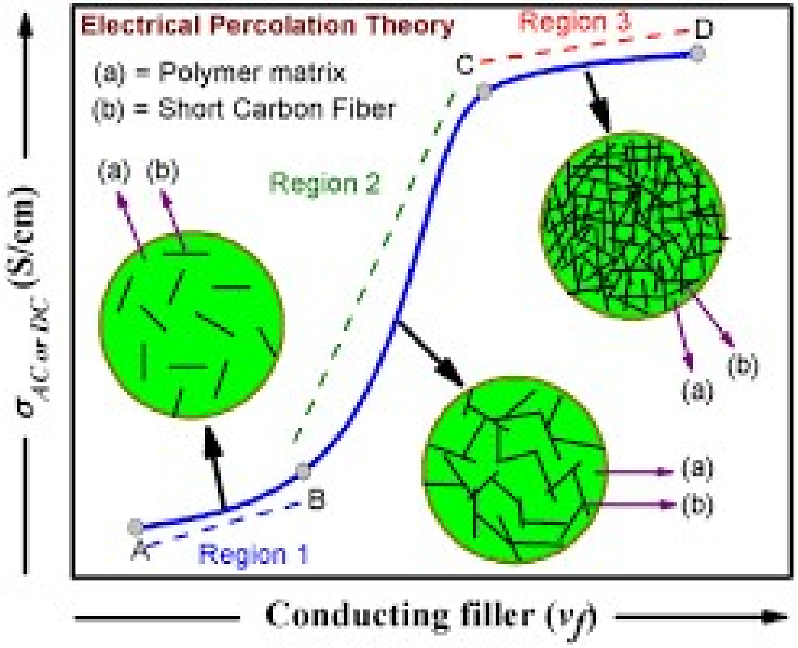
The pulling force of smart wire cannot be increased by supplying current beyond the recommended limit; this will damage it. However, two or more wires can be run in parallel. Two wires will give double the pulling force and so on. You must remember, though, that if the wires are connected in parallel, you also double the current needed to heat them up.

- Dimensionare tensione necessaria
- Osservare bending e misurare bending
- Confrontare con bending ottenuto usando due SMA wires

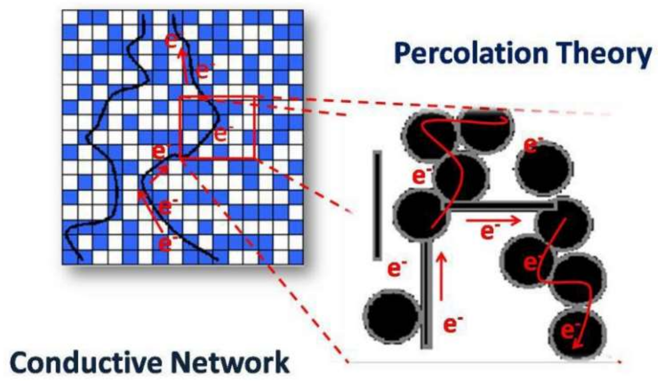
Quantum Tunnel Composite

Conductive polymers

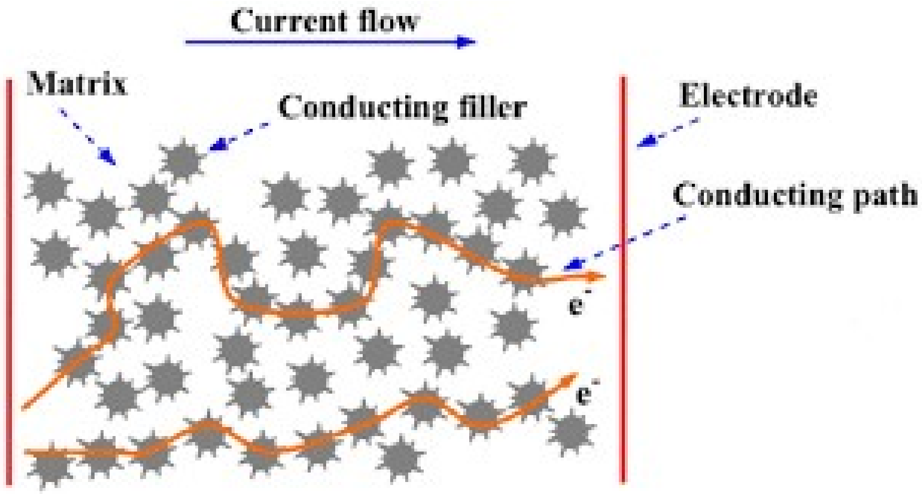
- inherently lower electric resistance
- composites, which contain conductive materials (e.g. carbon or metal particles)
  - **Percolation:**



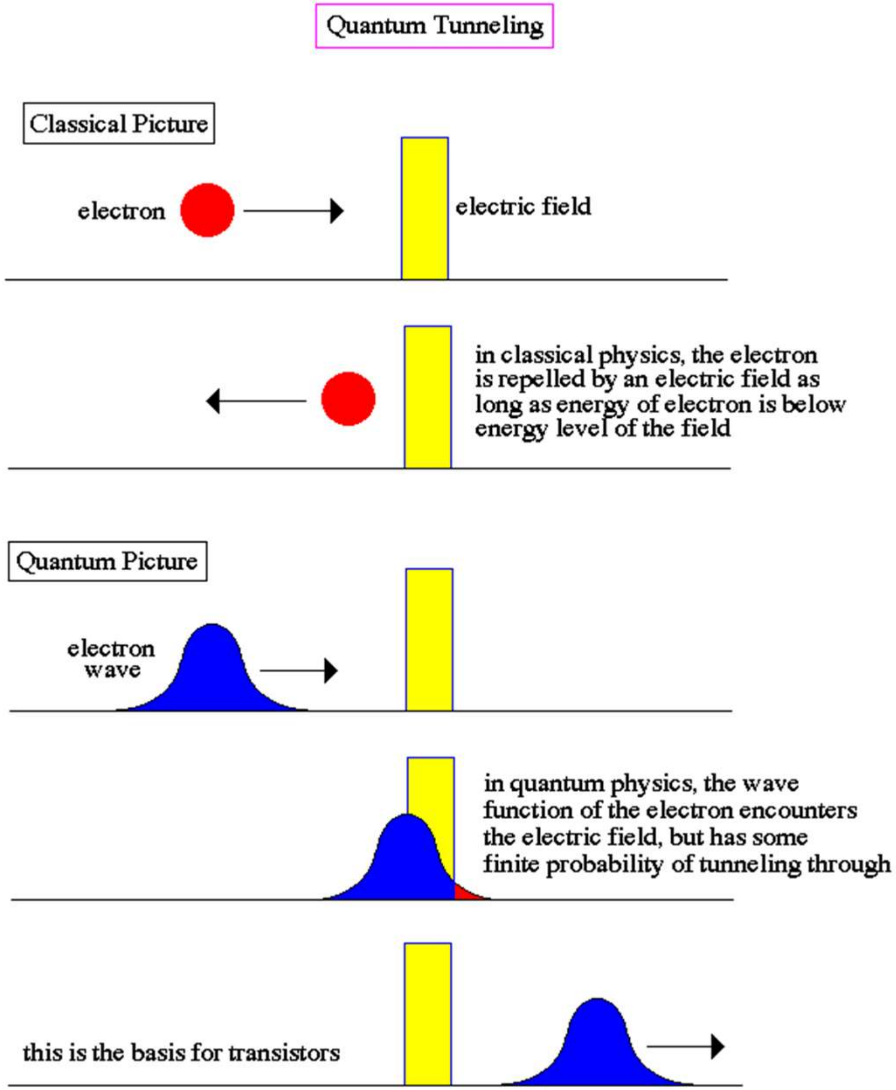
electrons are free to flow through conductive filler particles within the polymer matrix. If these filler particles contact one another, a continuous path is formed through the polymer matrix, which is an insulating material, for electrons to travel through. This path is called a conductive network.



Quantum Tunnel Composite

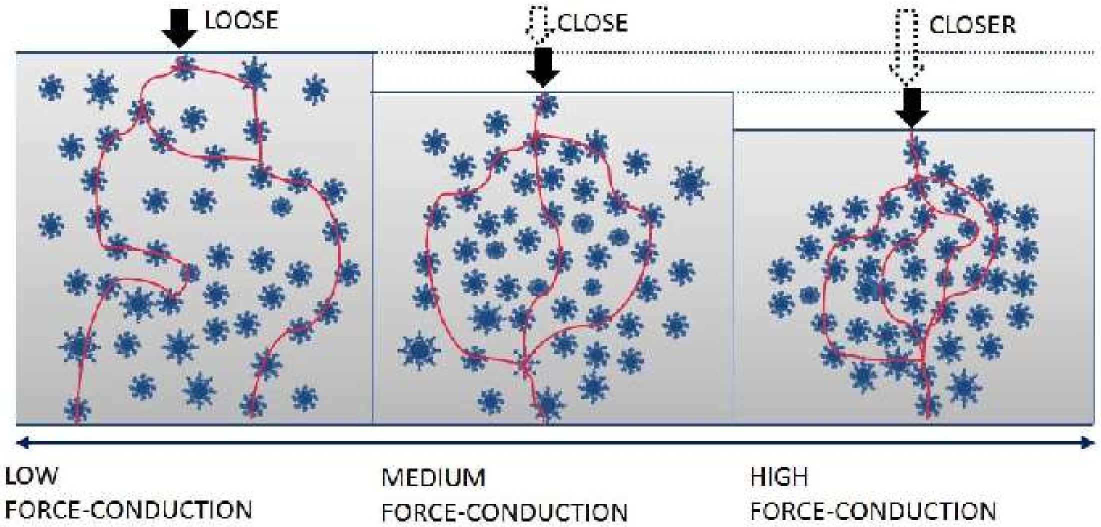


QTC contains tiny metal particles, but does not conduct by percolation.
Instead, electron passage occurs thanks to a process called **quantum tunneling**.

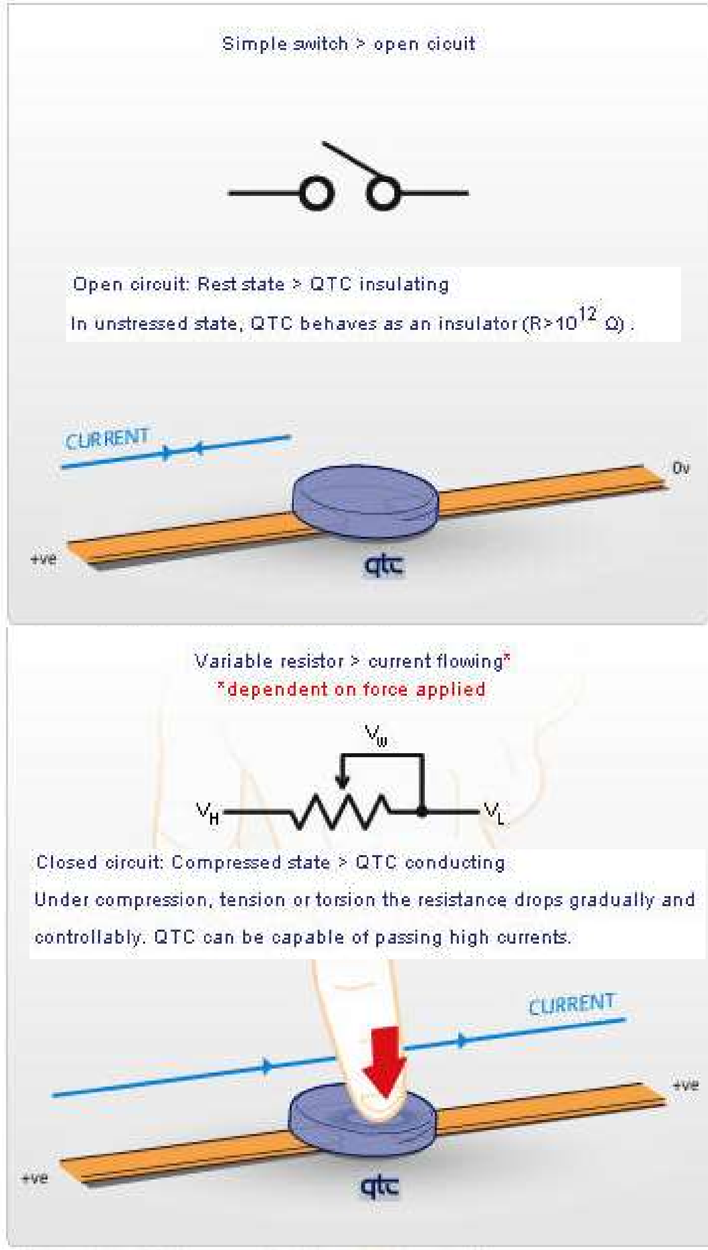


According to quantum theory, there is a certain **probability that an electron below the insulation barrier appears above it**.

The effect is far more pronounced than would be expected from classical (non-quantum) effects alone, as classical electrical resistance is linear (proportional to distance), while quantum tunnelling is exponential with decreasing distance, allowing the resistance to change by a factor of up to 10^{12} between pressured and unpressured states



Reducing the distance between the particles, the **tunneling probability** increases



Esercitazione SMA (LAB3)

- Dimensionare tensione necessaria
- Osservare e misurare bending
- Confrontare con bending ottenuto usando due SMA wires

Esercitazione QTC (LAB4)

- Montare la QTC pill i) in serie ed in ii) parallelo ad un led
- verificare come varia la luminosità del led al variare della pressione esercitata sulla QTC nei due casi.