

Memory metals - 3. Phase transition: acoustic properties

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Lab objectives

- Reflecting on the meaning of “phase” in a material
- Understanding the effects of crystal lattice modifications on macroscopic properties.
- Performing a quantitative analysis of acoustic properties during nitinol transition phase induced by temperature changes
- Linking experimental observations to atomic scale behaviour

Features



It can be performed with very simple equipment for a straightforward illustration of the analyze phenomena, with a high ‘wow-factor’ impact. Suitable for class demonstrations, science fairs and public outreach.



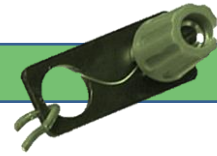
Implies possible systematic data collection and analysis with typical school lab methodology; difficulty level: easy.



In the lab electronic mobile devices (smartphones, tablets, etc.) can be effectively used to collect data (by audiorecording).



From the website www.nanolab.unimore.it, in the corresponding section, it is possible to download *the Complete Didactical Guide*. Inside the guide all the experiments within the thematic area “*memory metals*” are collected and described in a combined and highly integrated way. You will also find tips and didactical suggestions, detailed assembly instructions, different options for set ups and procedures, info about finding the necessary materials (outside standard lab equipment) and on available computer simulation or data analysis software. Curriculum alignment tips and examples on how to fit the experiments in usual classroom practice are offered together with references to research materials (external links and background reading).



What's to be observed

At the beginning a qualitative investigation of properties such as brightness, smoothness, pliability, sound transmission in two Nitinol bars of different chemical composition so that at room temperature they have two different stable phases.

Later on sound transmission and perceived pitch in the same bar with varying temperature are studied.

Equipment (for one working group only)

- 1 Ni51Ti49 bar (lung. 22 cm ; \varnothing 0,9 cm)
- 1 NiTiCu10 bar (same dim.)
- 1 INOX bar (same dim.)
- 2 temperature probes
- audio recording and analysis software¹
- microphone
- computer
- hammer
- oven glove
- hotplate
- heat resistant dish, $\varnothing > 20$ cm
- video analysis software
- tongs

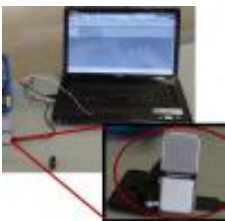
Procedure

A - Comparing austenite/martensite phase properties in nitinol bars



Take two nitinol bars A and M in austenite and martensite phase respectively at room temperature. You can compare and contrast their roughness colour, reflectivity, pliability and, most of all, different acoustic transmission. To test this last property just throw the bars to the floor and listen to the different sound produced: you will hear a ring (A) and a thud (M).

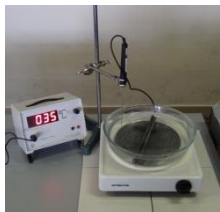
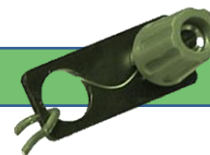
B - Setting up for audiorecording



Download and install the freeware recording and audio analysis software Audacity. Connect the USB microphone to the PC and make a preliminary test in the quietest room available, to verify whether your mic is able to detect and record even the muffled sound made by martensite. Record 1' of "silence": it will be useful to subtract and cancel the "background sound" in further recordings

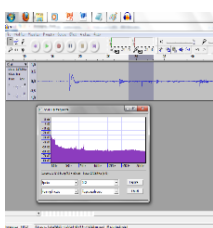
C - Sound transmission with varying temperature.

¹ Free software Audacity (<http://audacity.sourceforge.net/>)



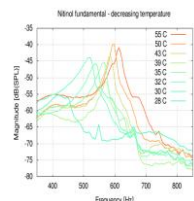
Make use of two bars with similar shape and dimensions, one made of nitinol, the other of iron. The bars are brought from 0 °C (this temperature is reached by storing them in the freezer for at least 15') to approximately 98°C through a thermal bath and then let to cool down spontaneously. During both heating and cooling the sound produced by the bars is recorded every 5°C. Hold the bars firmly in the spot corresponding to a node, check the bar temperature, start audiorecording and hit the bar repeatedly in the middle with a rubber hammer. (1° node position: distance from the edge = $0,224 \cdot L$, where L is the bar length) .

D - Sound analysis and data treatment



Obtain the sound spectrum with Audacity and extract the fundamental vibration frequency for each temperature. You can recognize it from the highest peak within the frequency gap in agreement with the theoretically obtained value. The comparison with the “silence” spectrum can be very helpful to recognize and dismiss anomalous peaks not belonging to the bar.

E - Data acquisition by smart phone – alternative modality



An alternative to the previously described procedure for sound acquisition consists in making use of a smart phone audio recording functionality. The microphones of smart phones are in fact suitable for high quality recording. The produced .wav files can be subsequently analyzed with Audacity software. Those who want to use smartphones for spectrum analysis as well will find free apps on line.

Finding materials and equipment

The **nitinol bars** have been manufactured and donated by IENI CNR Lecco. Larger diameter bars can be purchased by SAES Getters Group.

- The iron control bar can be purchased at any local hardware store. You can use almost any other metal bar beside iron provided dimensions are the same as Nitinol.
- The USB microphone with embedded sound card is a GO Mic by Samson. It costs approx. 39€ and it can be purchased at any music and instruments shop.

Software

- Audacity - free audio recording, editing and analysis software. Download at <http://audacity.sourceforge.net/>

Apps for Android

- Pure Audio Recorder http://www.appbrain.com/app/pure-audio-recorder-free/jp.gr.java_conf.nand.pure_audio_recorder_free
- SpecPro Analyzer 5,99 euro or [SpecScope Spectrum Analyzer](#) 0,99 euro.