Functionally Graded Orthodontic Archwires - Production And Characterization

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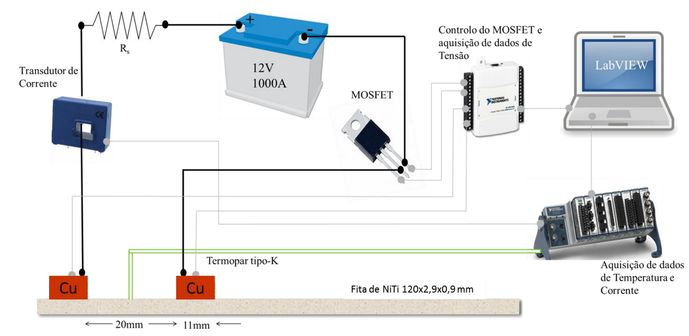
Abstract

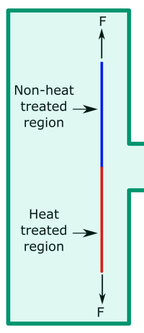
The introduction of graded functionality in commercial superelastic orthodontic archwires (Morelli SE) was analyzed. There are few studies concerning the manufacturing of the functionally graded Ni-Ti orthodontic archwires reported in the literature. The load developed by these wires depends on the geometrical characteristics, the temperature and the strain. Normally, the conventional archwires generate constant forces in a wide range of displacement during the orthodontic treatment [1]. In order to have different forces of actuation in the incisive region (lower) and in the molar region (higher), different fabrication strategies have been proposed, such as (i) laser welding different wire segments [2], or (ii) separate heat treatment of different segments in a special furnace [3]. In the present study, a functional gradient was introduced in a superelastic Ni-Ti orthodontic archwire (Morelli - SE) by localized heat treatment using Joule heat effect. DSC measurements at different positions of the wire show that a microstructural gradient is present in such treated archwires (Fig. 1-a). A localized analysis along the heat-treated archwire, using synchrotron radiation based X-ray diffraction (SR-XRD) was used to identify the microstructure of the heat treated archwire with a finer spatial resolution

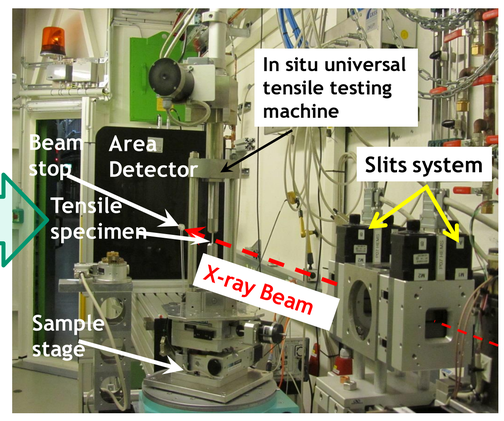
Experimental Details

Commercial available superelastic orthodontic wire



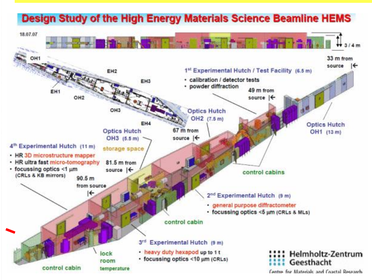
Localized heat treatment: 350 ºC / 5 min



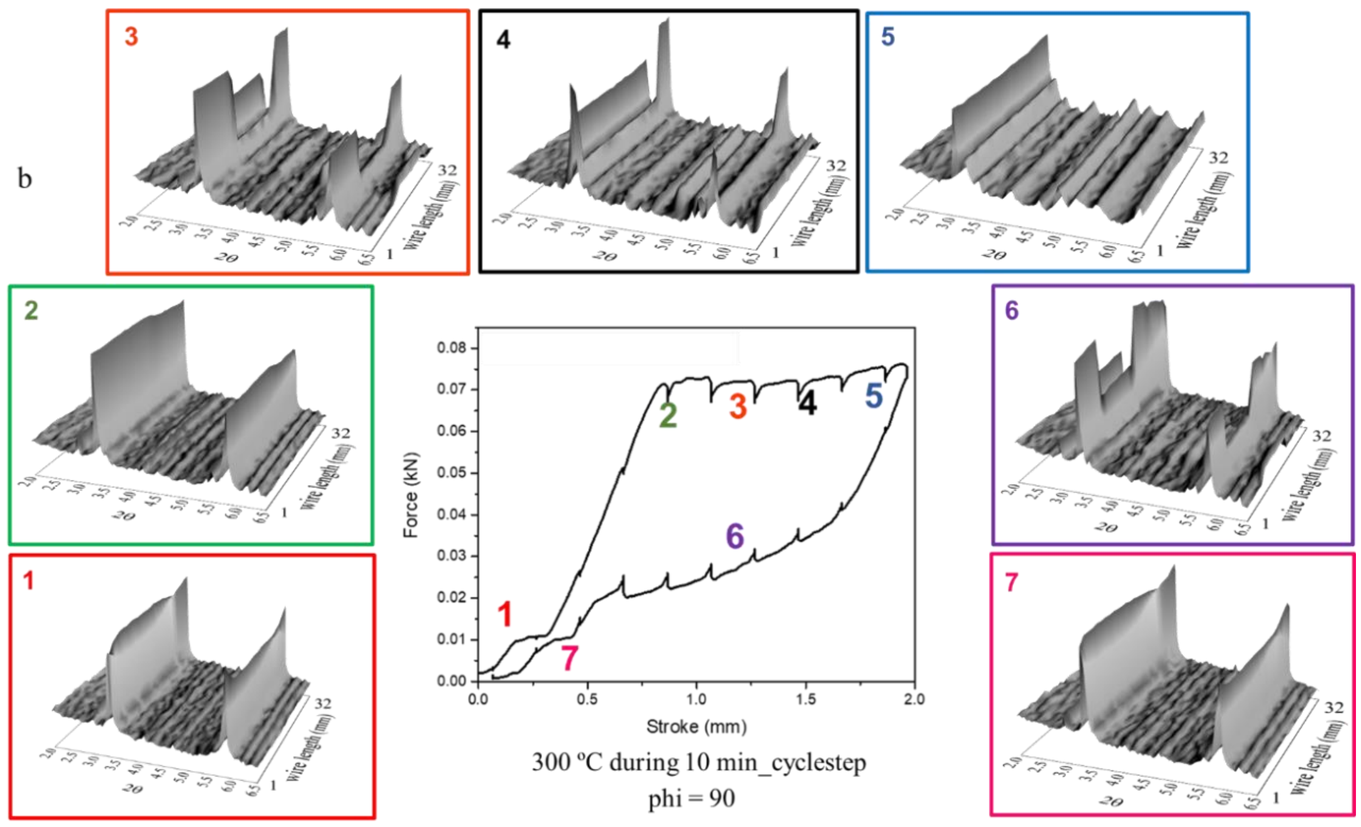


DESY/Petra III, Hamburg, Germany

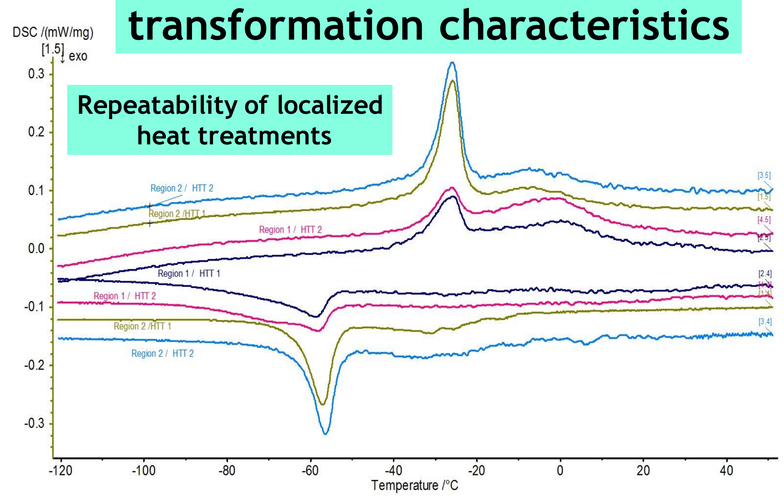
Spot size of 200 x 200 µm
wavelength: 0.1425 Å



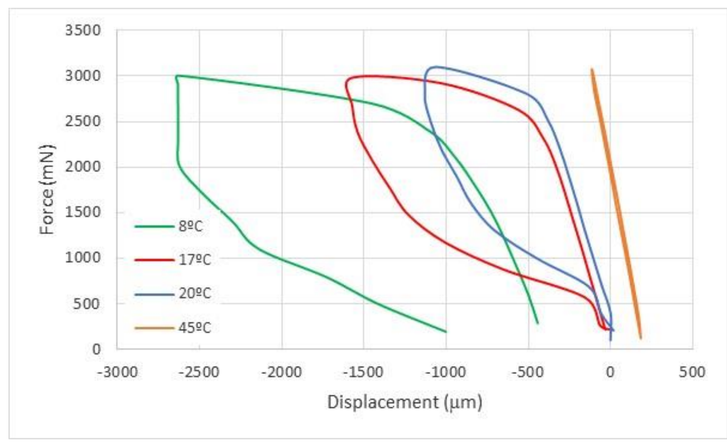
Results and Discussion



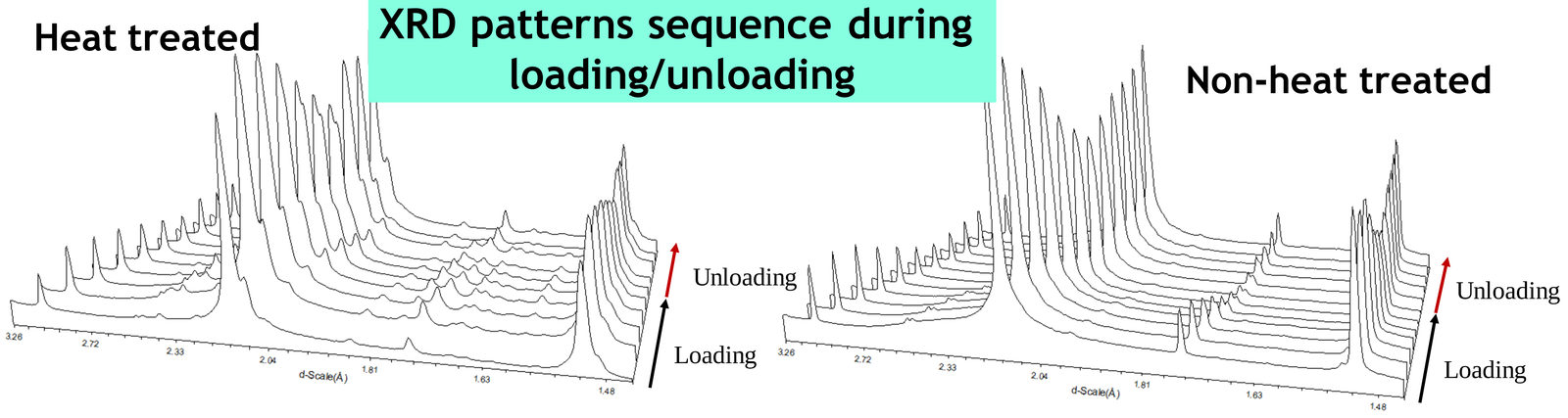
Orthodontic wire: transformation characteristics



Orthodontic wire: themomechanical analysis (3-point bending)



XRD patterns sequence during loading/unloading



Conclusions

A localized heat treatment at 300 ºC during 10 min has been applied, giving a functional gradient along the archwire length that has been put in evidence by XRD. In situ XRD during tensile test has shown the stress-induced B2 – B19' to start at the center of the heat treated segment. The precipitation phenomena, namely Ni_4Ti_3, originates a Ni depletion of the surrounding matrix that promotes increased transformation temperatures; also, these precipitates are responsible for the occurrence of the R-phase.

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