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How do the content of oxygen change superelastic properties of biomedical shape memory alloys?

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Titanium and its alloys are commonly used in biomedical industry due to their excellent biocompatibility and favorable mechanical properties. Certain applications need desired mechanical behaviors. Orthopedic and dental implants must possess a low Young's modulus (similar to that of a human bone) and high strength [1]. Cardiovascular stents need shape memory effect that enables a shape memory alloy (SMA) to be deformed at lower temperature and return to its remembered shape when heated. Endoscopic devices and archwires require a large recoverable strain which can be also achieved using certain Ti-based SMAs.
A relatively new class of Ti-Nb-based alloys is a promising candidate for use in medical industry. It is characterized by a non-toxic composition and peculiar mechanical properties, which can be adjusted with an increasing oxygen content. The oxygen content is hindering the full range phase transformation, which is responsible for the shape memory effect [2]. In other words, when the oxygen is added to Ti-Nb-based alloys, the hysteresis loop is diminished. For instance, the Ti-25Nb (at. %) alloy is characterized by a shape memory effect and the Ti-25Nb-1.0O (at. %) alloy has a superelastic-like behavior with high strength.
The research covers a comprehensive characterization from nano- to macroscale. Microscopic observations and phase content analyses are aimed at clarifying the effect of oxygen on suppressing the long-range phase transformation. The lattice modulations (nanodomains) distributed in the β phase, which acts as obstacles for the long-ranged martensitic transformation in oxygen-added Ti–Nb based alloys [3], were detected. Stress-strain curves confirmed a versatile potential of use of this class of materials in implant devices. Current, investigation focuses on the determination of macroscopic deformation and temperature fields using infrared thermography and digital image correlation during selected loadings of the oxygen-added Ti-Nb based alloys. The obtained data will be used to formulate constitutive equations and numerical models in the future.
The results are aimed at bringing a better understanding of the mechanisms of superelasticity in oxygen-added SMAs for a reliable application of these materials in biomedical industry.

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