Ni-Ti Surface With Depressed Ni Concentration Prepared By Plasma Immersion Ion Implantation

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Abstract

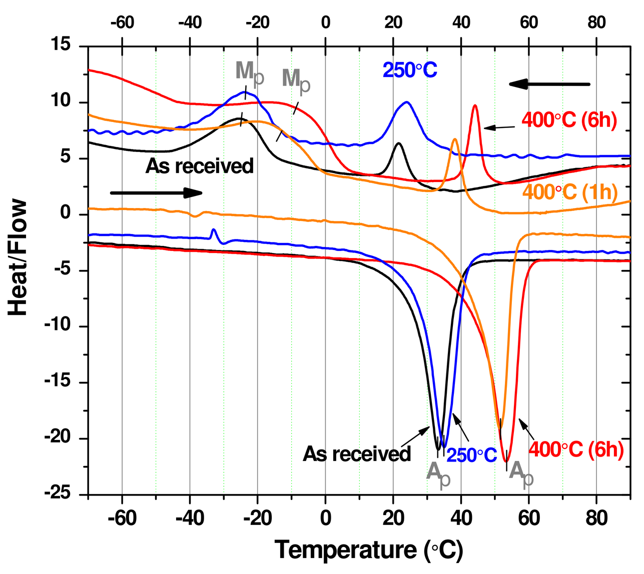
The plasma-immersion ion implantation (PIII) technique was used to modify and improve the surface of a Ni-Ti alloy (≈ 50.2 at.% Ni) for biomedical applications. The main goal has been the formation of a Ni-depleted surface, which should serve as a barrier to out-diffusion of Ni ions from the bulk material. Ion implantation of oxygen was carried out. The depth profiles of the elemental distribution in the alloy surface region, obtained by Auger electron spectroscopy (AES), confirm the formation of a Ti-rich oxide layer. The working plan also comprised ion implantation of nitrogen. In this case, the formation of titanium oxynitride (TiN_xO_y) was observed. The AES depth profiles show a Ni-depleted fraction for experiments performed with 40 keV.

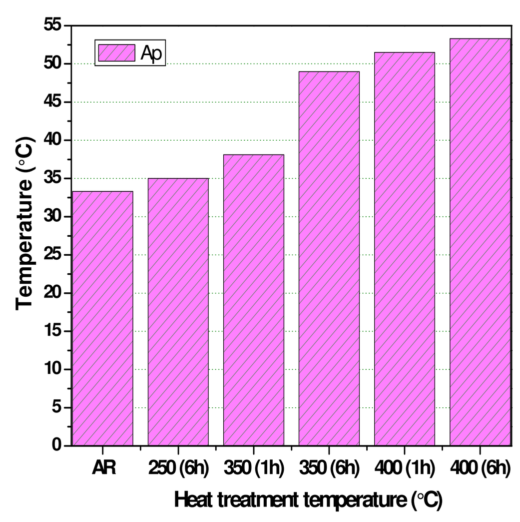
Experimental

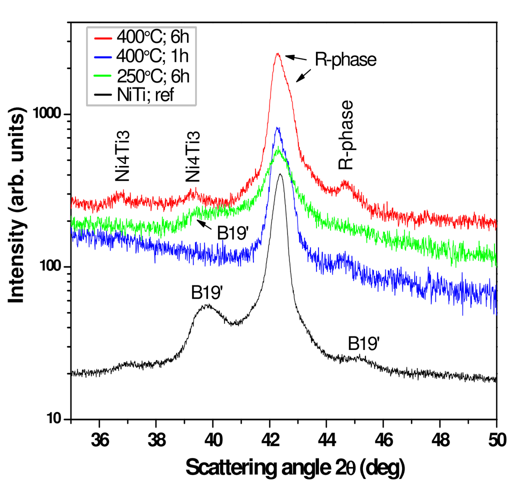
Aim: B2 phase ⇒ superelasticity

Ni-Ti alloy (≈ 50.2 at.% Ni): preliminary experiments were carried out to study the influence of the heat treatment temperature and duration. High temperatures promote the presence of the R-phase at body temperature.

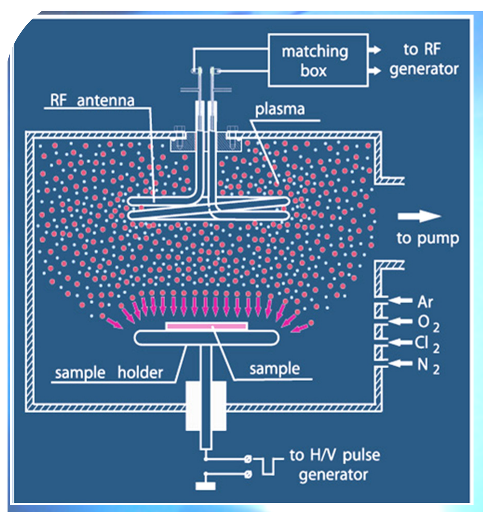
PIII: The sample holder was not intentional heated (T < 125°C)







For practical purposes, the productivity of beam-line ion implantation is often limited in particular when high ion fluences on larger areas are required. In addition, the treatment of three-dimensional items requires mechanical manipulation. These problems can be overcome by the PIII technique.



PIII parameters

- P_{base}: 3×10⁻⁴ Pa
- $P_{working}$: 0.2 Pa
- Power: 350 W
- Length: 5 µs
- Frequency: 400 Hz
- High voltage pulses of either 20 or 40 kV

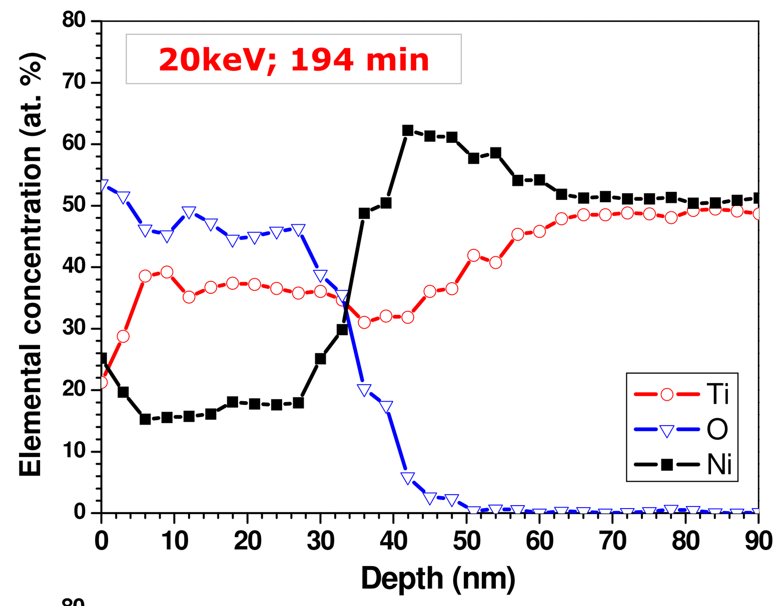
	(kV)	(min)
Oxygen	20	194
	40	25
Nitrogen	20	180
	40	60

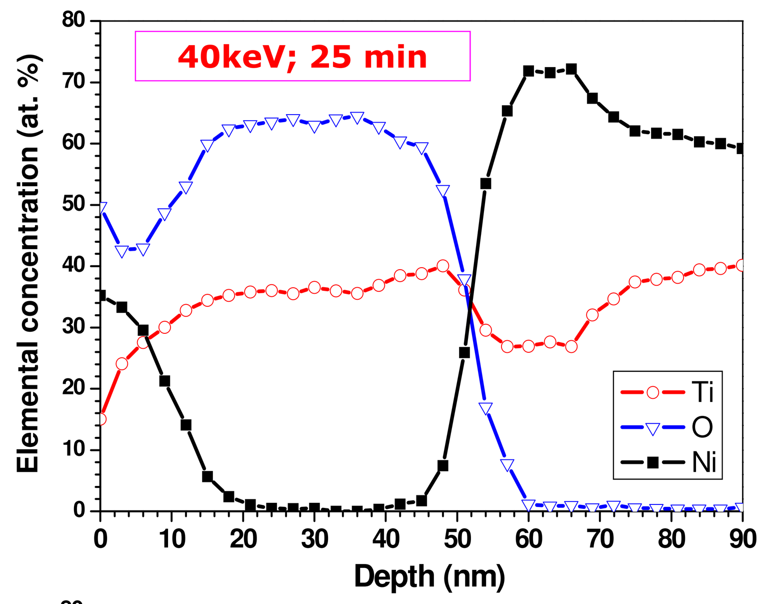
20keV; 194 min 40keV; 25 min 20keV; 180 min

Results

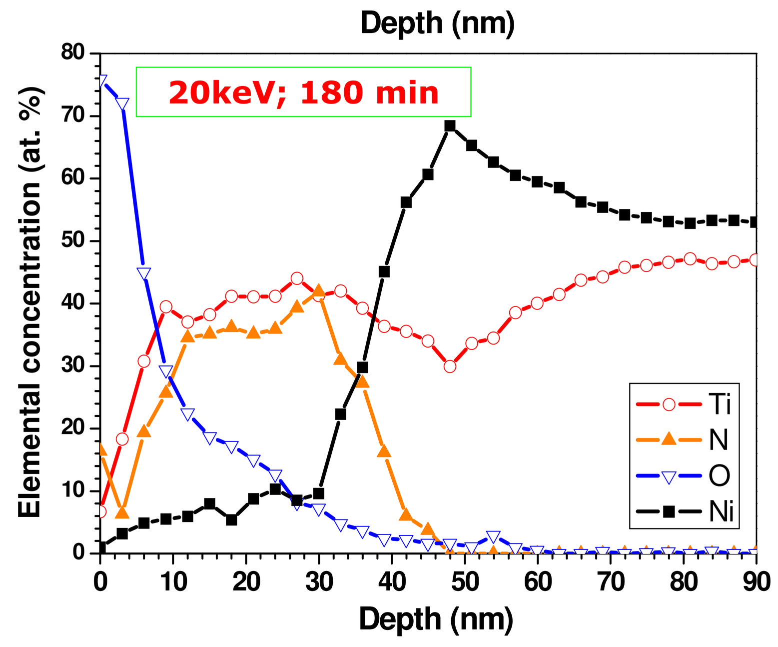
Compositional analysis

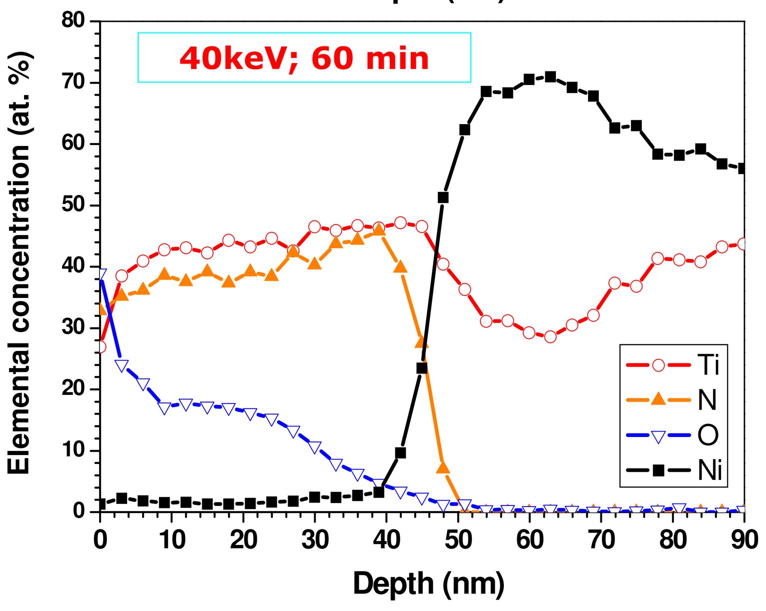
Oxygen



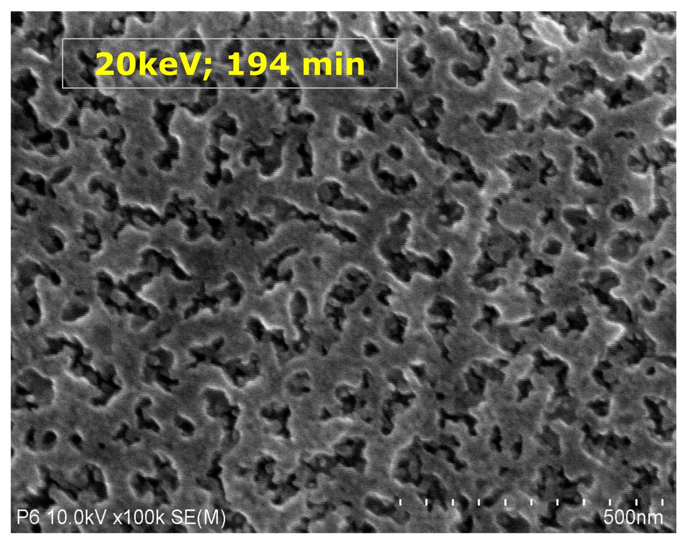


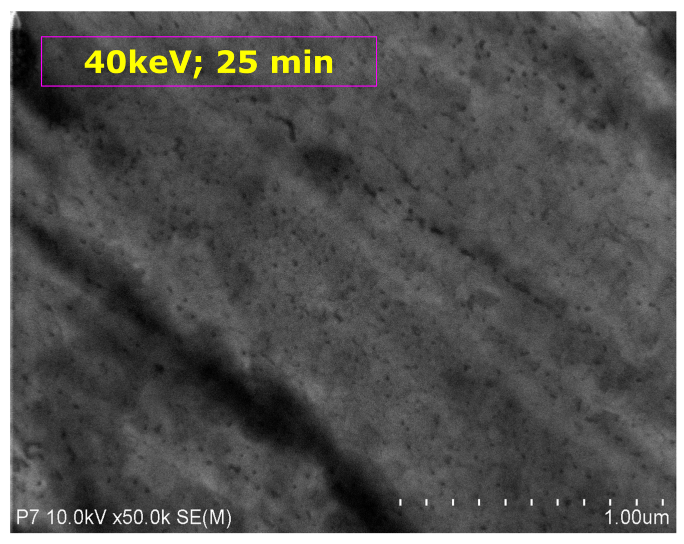
Nitrogen

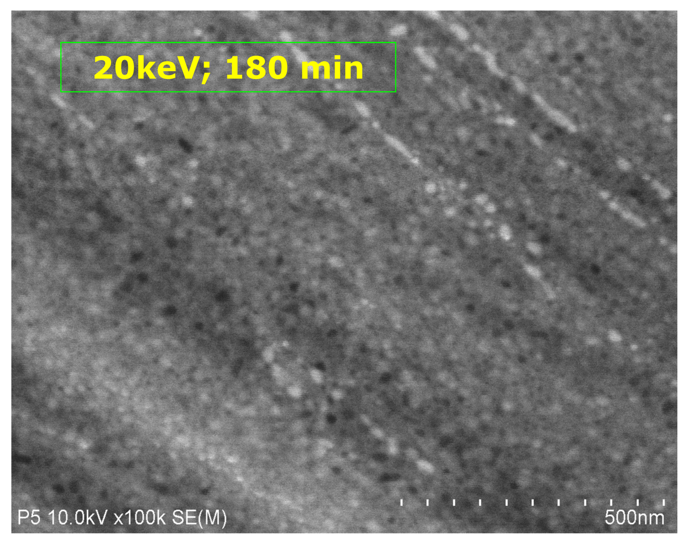


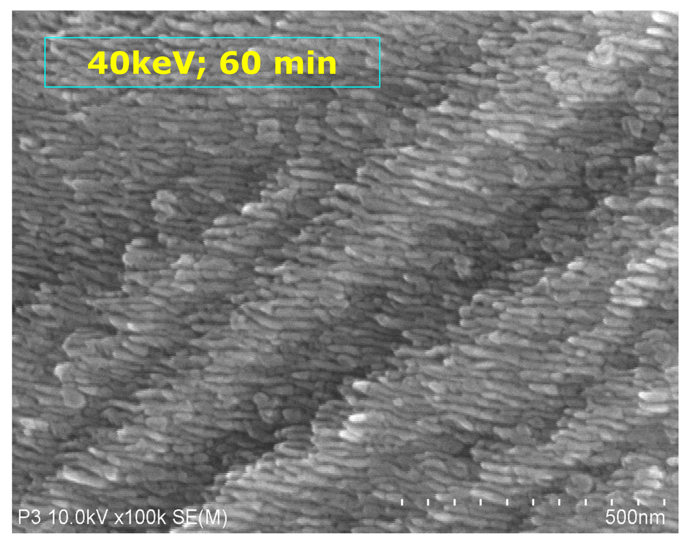


SEM observations



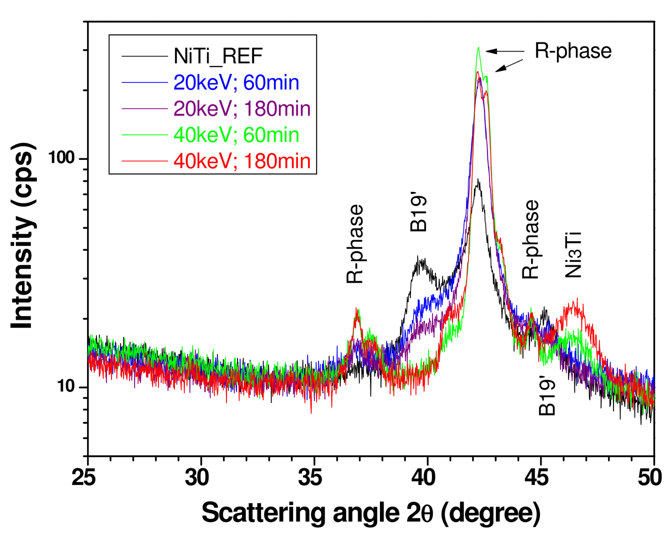


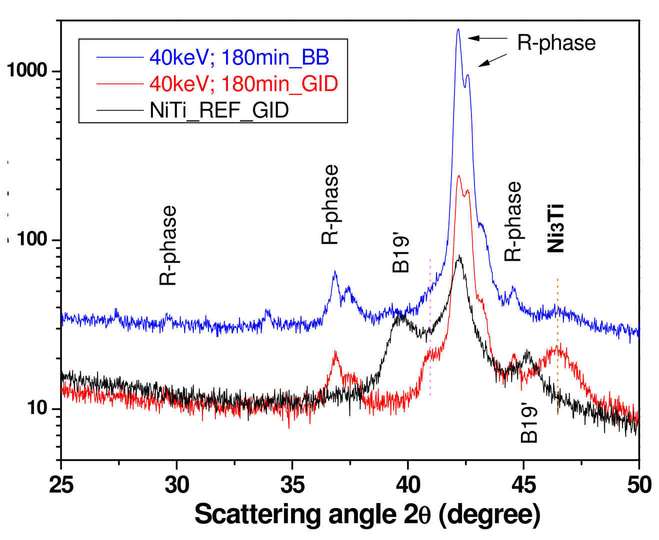


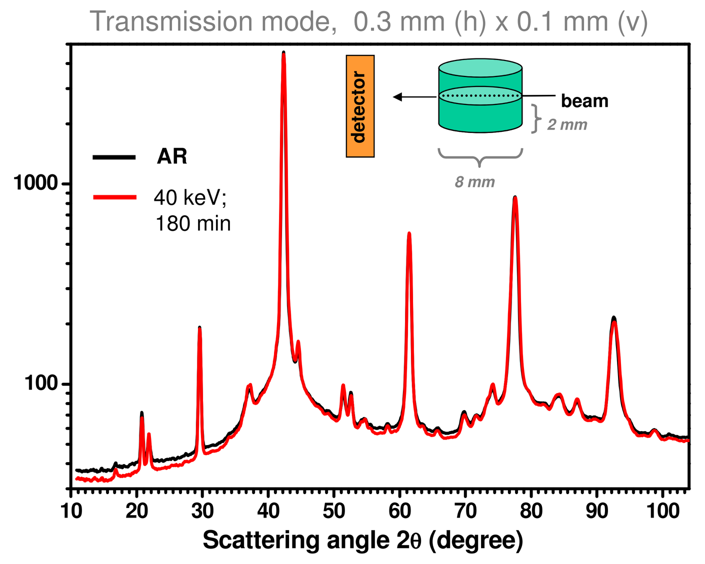


XRD studies at RT

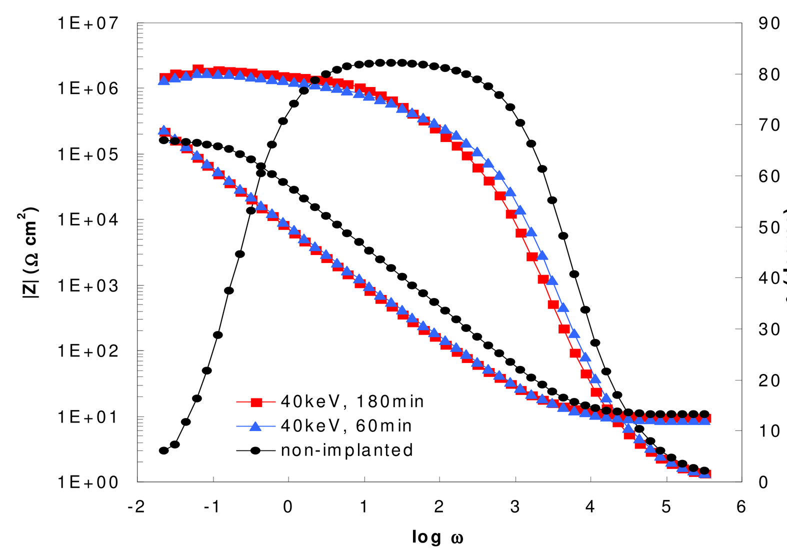
Nitrogen







Electrochemical impedance spectroscopy



Summary

- PIII creates a graded interface between the modified surface and the bulk.
- It is possible to tailor the properties of the top layer, especially its barrier function against the out-diffusion of Ni.
- The high value of film resistance (Electrochemical impedance spectroscopy) suggests a very good corrosion resistance, which can be associated with the low Ni concentration at the surface of film.
- The high temperature necessary for thermal oxidation and nitriding would lead to alteration of the phase transformation characteristics and loss of specific mechanical properties of the alloy.

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