Coating of nitinol surface by titanium dioxide films grown by atomic layer deposition

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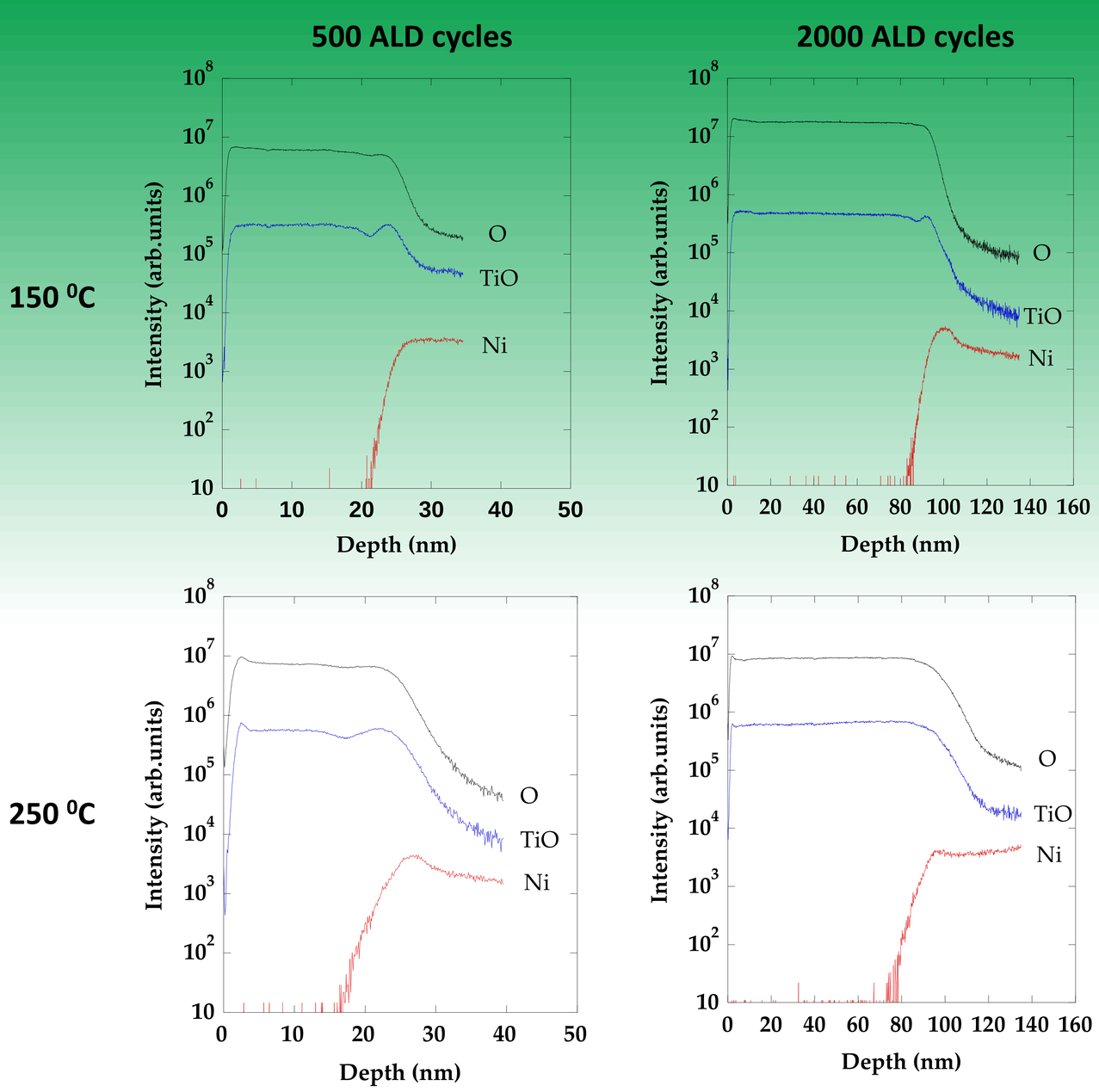
Introduction

Nitinol (NiTi), a nearly equiatomic alloy of Ni and Ti atoms, with its unique features such as shape memory, superelasticity and kink resistance, has found many applications in biomedical device production. However, the release of Ni from nitinol is of considerable concern, as Ni atoms are known to be allergenic and toxic. Therefore, modification and coating of NiTi is highly desirable in order to improve the biocompatibility and corrosion resistance of material and prevent the release of Ni into human body.

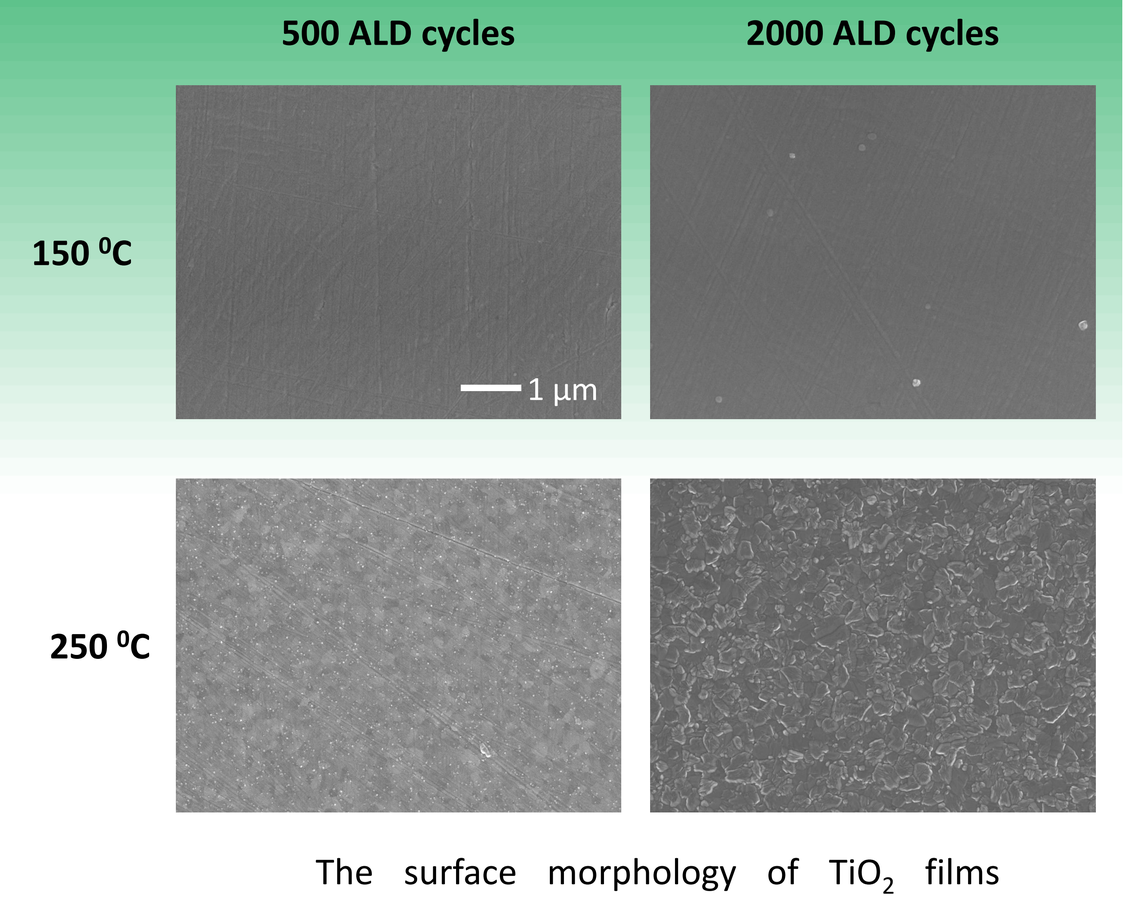
Titanium dioxide (TiO_2) is a perfect candidate for the biocompatible coatings on biomedical materials, due to its biological and chemical inertness, non-toxicity and long-term stability against corrosion. In this work we have used atomic layer deposition (ALD) technique for the synthesis of thin TiO_2 films on NiTi substrates. Films were deposited in a wide temperature range (150 – 250 ^{0}C), using $TiCl_4$ and water as ALD precursors. SIMS spectrometry was employed for the investigation of Ni diffusion into TiO_2, while the surface morphology and the chemical composition of deposited films were analysed with SEM microscopy and XPS spectroscopy.

SIMS analysis



In-depth SIMS profiles of TiO_2 films recorded by measuring the negative ions of O, Ni and TiO (with 5 keV Cs^+ primary ion beam). Diffusion of Ni into the TiO_2 film is more pronounced in the films deposited at 250 ^{0}C (polycrystalline films), compared to films grown at 150 ^{0}C (amorphous films).

SEM analysis

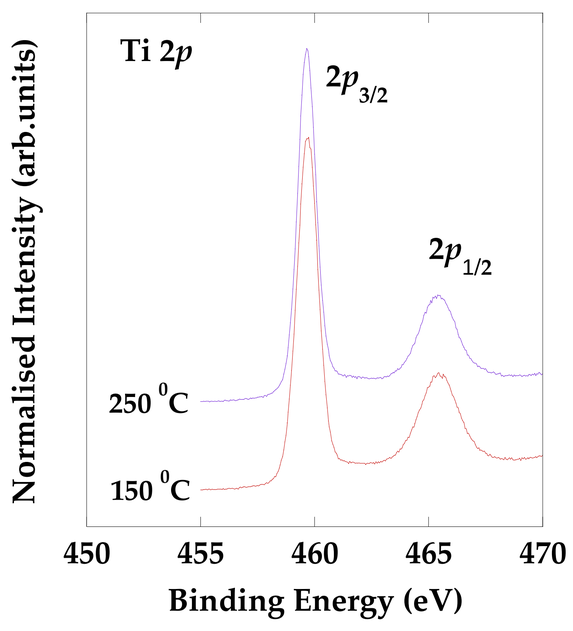


The surface morphology of TiO_2 films deposited at different substrate temperatures. Images were recorded at a magnification of 20000 times with the gentle electron beam of 0.7 keV. Films deposited at 150 ^{0}C show amorphous structure, in contrast to polycrystalline films grown at 250 ^{0}C.

XPS analysis

XPS spectra measured around Ti 2*p* core levels, for samples deposited at 150 ^{0}C and 250 ^{0}C, show a structure characteristic for a pure TiO_2.

2000 ALD cycles



Conclusion

- ALD synthesis of TiO_2 produces amorphous films at the deposition temperature of 150 ^{0}C , while the films grown at 250 ^{0}C show polycrystalline structure.
- SIMS measurements show that an amorphous phase of deposited films act as a better diffusion barrier for the release of Ni in TiO_2, compared to polycrystalline films.

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