Forschungszentrum Dresden Rossendorf

ROBL-CRG at ESRF

FACULDADE DE CIÊNCIAS E TECNOLOGIA UNIVERSIDADE NOVA DE LISBOA

Texture development and phase transformation behaviour of sputtered Shape Memory Alloy Ni-Ti films

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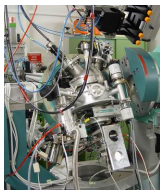
Abstract: Ni-Ti SMA films are attractive materials for microfabrication and integration in micro-miniature systems composed of mechanical elements, actuators, sensors and electronics made on one chip. However, there are still important issues unresolved like formation of film texture and its control as well as substrate effects. It is essential to identify and control their preferential orientation since it is a crucial factor in determining the shape memory behaviour. Widening the scope of previous experiments concerning the influence of the deposition parameters on the Ni-Ti films structure [1-4], the incorporation of a TiN intermediate layer was tested [5]. Here, it is established a clear relationship between the TiN substrates and Ni-Ti texture development (B2 phase) and it is shown that the distinct crystallographic orientations of the Ni-Ti films influence their phase transformation behaviour. The influence of a substrate bias voltage on the preferential orientation of the B2 phase and transformation temperatures is as well revealed.

Experimental:

In-situ XRD during growth and annealing of the films



Deposition chamber mounted into the 6-circle diffractometer of *ROBL* at *ESRF*.

Deposition parameters

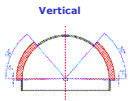
Targets: Ni-Ti *(51 at% Ti)* + Ti

Power: Ni-Ti : 40 W } *Ni-Ti*
Ti : 20 W }

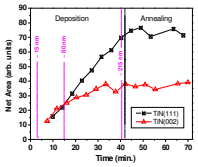
Ti : 80 W } TiN

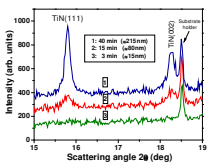
P = 0.42 Pa T_{sub} = 470°C

Scattering Geometry

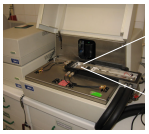


λ = 0.675 Å

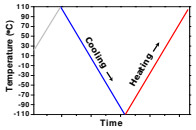




Electrical Resistivity (ER) during temperature cycling



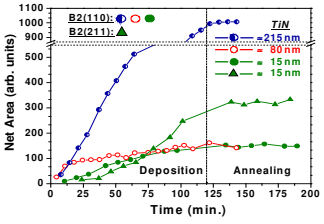
BIO-RAD HL 5550 BIO-RAD HL 5550

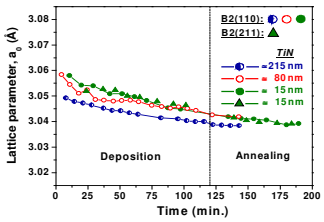


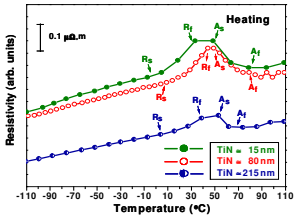
Ni-Ti films attached to the substrate.

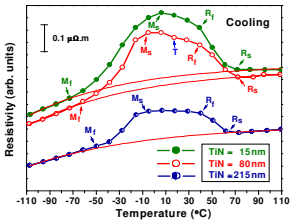
Results:

Ni-Ti films: Without substrate bias voltage



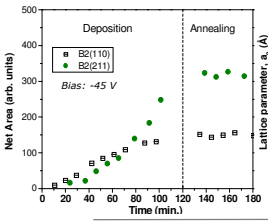


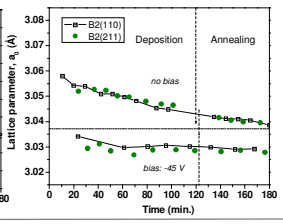


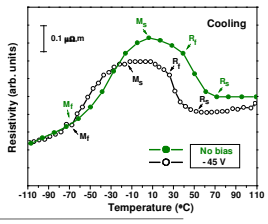


Ni-Ti films: With substrate bias voltage

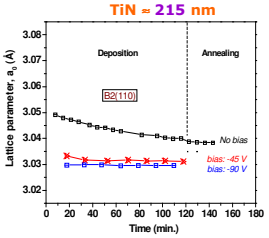
TiN ≈ 15 nm

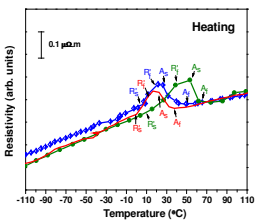


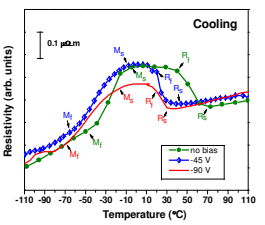


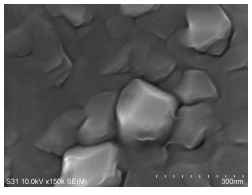


TiN ≈ 215 nm

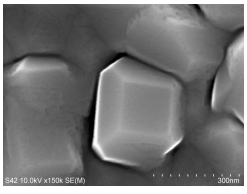




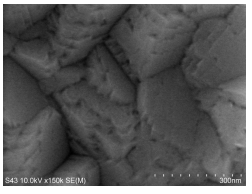




0 V



-45 V



-90 V

Summary:

- The magnetron-sputtering chamber installed at ROBL proves to be a very efficient instrument to follow *in situ* the evolution of the structure of the Ni-Ti growing film.
- A TiN buffer layer is a promising tool concerning the manipulation of the crystallographic orientations of Ni-Ti films (and an efficient diffusion barrier).
- The preferential orientation of the sputtered Ni-Ti films is also influenced by the application of a substrate bias voltage.
- The control of the energy of the bombarding ions is a tool for the manipulation of the transformation temperatures.
- Films presenting the shape memory effect above RT have been produced.

References:

[1] R.M.S. Martins *et al.*, *Nucl. Instr & Meth B* 238 (2005) 319.
[2] R.M.S. Martins *et al.*, *Appl. Phys. A* 84 (2006) 285.
[3] R.M.S. Martins *et al.*, *Mater. Sci. Eng. A* (*doi:10.1016/j.msea.2006.12.225*).
[4] R.M.S. Martins *et al.*, *Appl. Phys. A* (*doi:10.1007/s00339-008-4397-2*).
[5] R.M.S. Martins *et al.*, *Sens. Actuators B* 126 (2007) 332.

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