SIMULTANEOUS MEASUREMENT OF ELECTRICAL RESISTIVITY AND X-RAY DIFFRACTION DURING R-PHASE FORMATION ON Ni-Ti SMA

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ABSTRACT

In situ XRD has been used by the authors to study the structural changes during (i) the crystallization of Ni-Ti thin films [1], (ii) the growth of Ni-Ti thin films by sputtering [2-4], and (ii) the transformation characteristics of bulk N-Ti subject to thermomechanical treatments [5-6]. The phase transformations of Ni-Ti SMA can also be investigated by measuring some physical properties such as electrical resistivity (ER) as a function of temperature. During cooling of Ni-Ti SMA from B2-phase, the resistivity value decreases linearly with the temperature down to *Rs* , where R-phase self-accommodated (by twinning) starts to be formed. Twinning in an alloy matrix results in electron scattering, which in turn leads to the increase of the ER [7]. Additional cooling below *Rf* promotes the continuous increase of rhombohedral distortion angle of the R-phase. It is assumed that this rhombohedral distortion is the reason for a further increase of ER (between *Rf* and *Ms*). Below *Ms*, this distortion is relaxed by the R-phase transforming to monoclinic B19' martensite, giving a gradual decrease of ER. These transformations can be thermally induced or stress induced and the electrical resistivity variations that are associated may be used to monitor different types of situations [7].

The simultaneous measurement of the electrical resistivity and XRD during thermal cycles allows establishing a direct correlation between features of electrical resistivity variation and structural changes. It is usually assumed in the published literature [8] that, during cooling, the B2 to R-phase transformation shows a significant electrical resistivity increase associated to (i) formation of R-phase from Rs to Rf, followed by (ii) increasing rhombohedral distortion (with no further R-phase formation).

Data obtained during beamtime at ESRF (2009 and 2010) confirmed that the rhombohedral distortion is notorious (variation of the peak position of (211) and (300) from R-phase) when cooling below the temperature usually identified as Rf. But data obtained also show that the net areas of R-phase peaks are still increasing during the last step of the electrical resisitivity increase. These results suggest that, besides a significant rhombohedral distortion below the temperature usually assigned as Rf, there is still new R-phase formation.

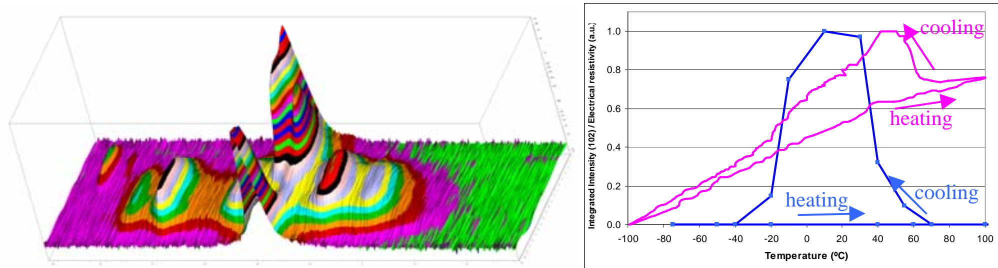

Figure 1: (a) Overall phase transformation sequence of a Ni-Ti thin film during cooling from 100ºC to – 100ªC, followed by heating to 100ºC.. (b) Superposition of integrated intensity of R-phase peak (102) and electrical resistivity variation as a function of temperature

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