Investigations on precipitation phenomena in a SMA (Ni-Ti)

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INTRODUCTION: The Ni-Ti alloy (Shape Memory Alloy - SMA) can be used for medical applications if its special property could develop in the range of the common human body temperature. The common control [1] of the heating/cooling transformation temperatures consist in the use of adequate alloy composition with equilibrium structure. A new idea [1, 2], studied in the last period, is to use a Ni rich Ni-Ti alloy and to apply a heat treatment (aging) to obtain the precipitation of specific equilibrium/non-equilibrium Ni_xTi_y compounds. In this manner, the changes of chemical composition of base solid solution (NiTi) allow to modify and control the austenite (A)/martensite (M) transformation temperatures.

MTHODS: The studied alloy was a Ni-Ti one (50.6 Ni, 49.4 Ti). It was delivered as hot and cold rolled sheet (0.5×5.9mm), annealed 1h at 1073K and water cooled, with equilibrium structure (NiTi solid solution). The aging was performed at two different temperatures, 673K and 773K, with four different durations, 3.6ks, 10.8ks, 18ks and 36ks. Antioxidant protection of the samples was solved by means of their encasing in aluminum sheet (0.1mm). Final cooling after treatment was made in water. The samples were investigated by microscopy (SEM and EDX) and micro-hardness. DSC determinations were made on aged samples in comparison with the reference one (in equilibrium state). The heating/cooling rate was 5K/min and the studied temperature range of 263K…343K.

RESULTS: Precipitated compounds identified by EDX were Ti_2Ni, Ti_3Ni_4 and most probably Ti_3Ni.

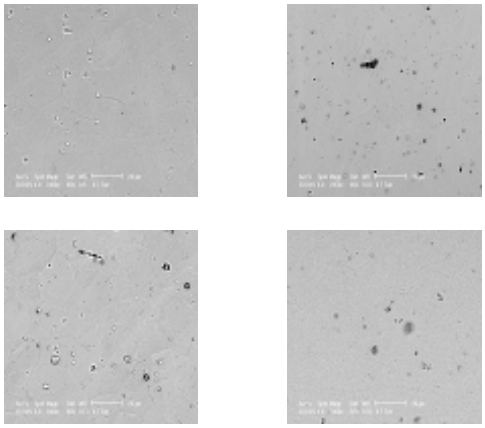

Fig. 1: SEM observations: Effect of aging temperature on precipitation - after 1 h: 673K (up-left), 773K (up-right), after 10 h: 673K (down-left), 773K (down-right).

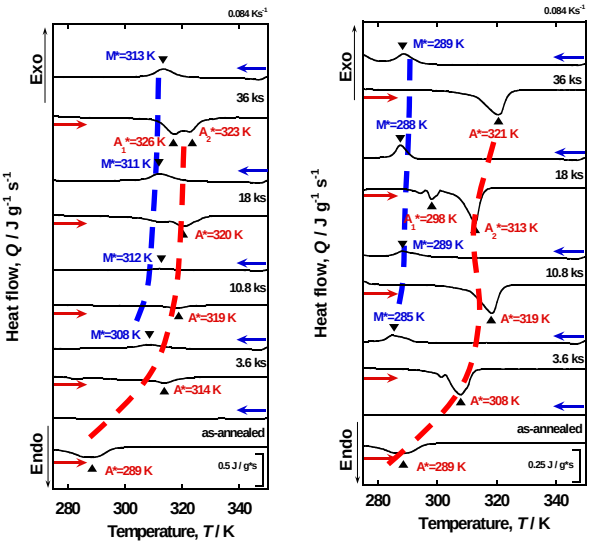

Fig. 3: DSC study on aging temperature and time effects on A and M transformation temperatures.

DISCUSSION & CONCLUSIONS: Increasing aging time, at constant aging temperature, for both treatments, determines systematical displacements of transformation start/finish points for both transformations. For the aging at 673K the cooling transformation (M) is happening in the range 300…320K, and for the aging at 773K, it is happening in the range 280…300K. Transformation points at cooling (M) and heating (A) are significant displaced at higher temperatures. The influence is more evident for the transformation at heating (A). It is also visible that aging temperature increasing from 673K to 773K, determines lower transformation points for both transformations (A and M) for all aging durations. It is obvious that this technological procedure allows for a reasonable control of the shape memory effect, related with the direct use of such material for arterial stents, which have to change their shape below the normal temperature body.

REFERENCES: [1]K. Otsuka, X. Ren (2005) *Progress in Materials Science* **50**:511-678. [2]D. Tomus, K. Tsuchiya, et al (2004), *Materials Transactions* **45**:219-224.

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