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Characterization of Ti-Ni-Pt high temperature shape memory alloys

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Abstract –Thirteen ternary Ti-Ni-Pt high temperature shape memory alloys (HTSMAs) near the 50% Ti line have been characterized using TEM, SEM, XRD, EBSD, and DSC techniques. The nature of the various phases and their transformation sequences indicate that the shape memory characteristics are sensitve to Pt content as well as precipitation of secondary and tertiary phases. Further, it is shown that these phases have complex transformation behaviors which vary considerably with thermal history.

There are currently many applications for Nitinol-based shape memory alloys (SMAs) that contain nearly equiatomic amounts of Ni and Ti. However, one limitation of these SMAs is that the characteristic shape memory effect may not be exploited above roughly 100°C [1]. Recently, there has been a growing interest in SMA's with Increased transformation temperatures so that they could be used in higher temperature applications in such industries as aerospace, automotive, and power-generation. For example, several applications for HTSMAs in jet engines have been identified and include variable area/geometry inlets, flow control devices, active clearance controls, vectored exhaust nozzles & VANS, and core exhaust chevrons [2]. Alloying additions of Pd, Pt, Rh, Au and Zr all increase the transformation temperatures that are responsible for the utility of shape memory alloys, and Pt has been shown to have the greatest effect [3]. Unfortunately, little is known about the phase equilibria in the ternary Ni-Ti-Pt system even though its alloys show the greatest promise as potential HTSMAs.

In this study, thirteen Ni-Ti-Pt alloys slightly off the Ti/(Ni+Pt) = 1 line (50%Ti) (Figure 1) were examined after different thermal treatments. It is well known that in the binary Ni-Ti system, slightly Ti-lean alloys have been shown to contain a metastable Ti_2Ni_3 phase which is tetragonal at high temperature and transforms to a structurally-related orthorhombic structure at lower temperatures [4]. In the current study, a similar orthorhombic phase has been observed in the Ti-lean Ni-Ti-Pt alloys after certain heat treatments (e.g., Fig. 2) although it is unclear if the structures and transformation sequences are identical. The results from a series of alloys and heat treatments will be presented and discussed, as will the implications of these observations on the suitability of these alloys in real applications.

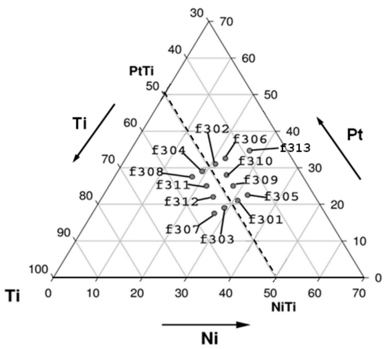

Figure 1. Ternary plot presenting the thirteen Ni-Ti-Pt alloys investigated.

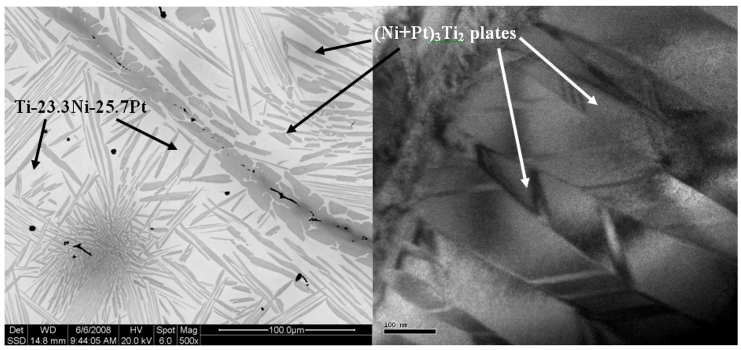

Figure 2. BSE image (left) and bright field TEM image of a Ti-23.3Ni-25.7Pt alloy, heat treated at 1050°C for 72hrs and furnace cooled. As seen in the TEM image, the darker (low Z) phase is $Ti_2(Ni,Pt)_3$, which contains faults that appear to be related to the tetragonal to orthorhombic transition reported in the binary alloys.

References

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