Elastic-Constant Behavior in Ti-Ni-Based Alloys

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The following is a Web Extra expanding upon the introductory article, **"Science and Technology of Shape-Memory Alloys: New Developments,"** by Kazuhiro Otsuka and Tomoyuki Kakeshita, Guest Editors, published in *MRS Bulletin* **27** (2002) pp. 91–100.

The elastic constants (*c*) of Ti-Ni-based alloys in the vicinity of the M_s temperature (the temperature at which the martensitic transformation starts upon cooling) in the parent phase were systematically measured recently as a function of temperature to study the precursor phenomena of the alloys, as shown in Figure 1. The primary characteristic of the alloys is that both c' and c_{44} decrease with decreasing temperature. The softening in c' is common in the thermoelastic transforming alloys, as Zener predicted, but the softening in c_{44} is unusual, since c_{44} usually increases with decreasing temperature, even in most transforming alloys. The softening in c_{44} was recently correlated with the creation of monoclinic martensite (B19′), since c_{44} corresponds to the resistance for the shear {001}⟨110⟩, which is required to create the monoclinic angle of B19′ martensite.

Although the temperature-dependence of c' and c_{44} is similar, as the second characteristic, the temperature-dependence of the elastic anisotropy ($A = c_{44}/c'$) differs, depending upon the type of martensitic transformations in the alloy system, as shown in the figure. In other words, for the alloys transforming from B2 to B19′, *A* decreases with decreasing temperature, while for the alloys transforming from B2 to B19, *A* increases with decreasing temperature; for the alloys transforming from B2 to R, *A* becomes flat near the M_s temperature.

These behaviors can be understood in the following way. In the first case, c' and c_{44} become comparable with decreasing temperature by causing a decrease of *A* with temperature. Thus, both {001}⟨110⟩ shear and {$\bar{1}$10}⟨110⟩ shear operate, and lead to B2–B19′ transformation. On the other hand, in the second case, {$\bar{1}$10}⟨110⟩ shear becomes predominant, since *A* increases with decreasing temperature, which leads to a B2–B19 transformation. In the third case, we cannot correlate the flatness of *A* near M_s, but we also notice in this case that c' takes the same value at the M_s temperature, irrespective of the composition of the alloy, which is justified by the Landau theory. For more details, see the following recent references.

References

1. X. Ren, N. Miura, J. Zhang, K. Otsuka, K. Tanaka, M. Koiwa, T. Suzuki, Yu.I. Chumulyakov, and M. Asai, *Mater. Sci. Eng., A* **312** (2001) p.196.
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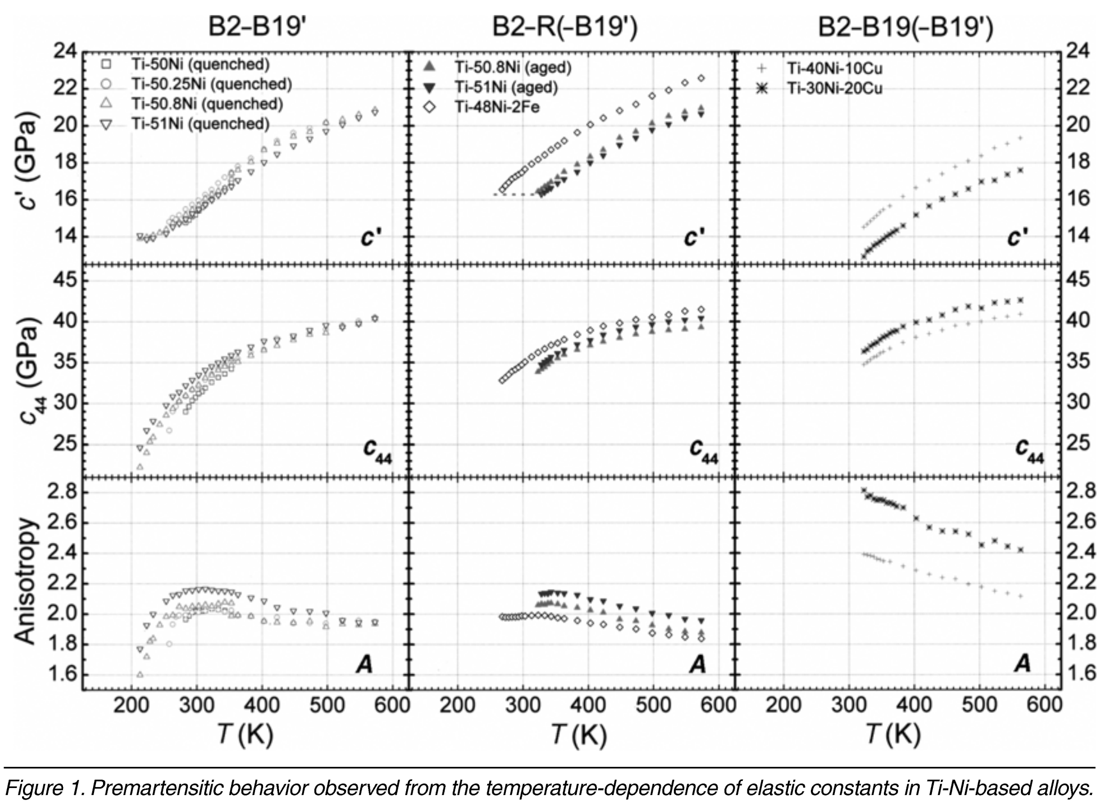

Figure 1. Premartensitic behavior observed from the temperature-dependence of elastic constants in Ti-Ni-based alloys.