**TA Instruments**

Thermal Analysis & Rheology

# Thermal Analysis Application Brief

## Detection of Beta Transus in Titanium Alloys by Differential Thermal Analysis (DTA)

Number TA-131


## SUMMARY

Many non-polymer materials such as metals, minerals, and glasses exhibit transitions at temperatures above 725°C limit for DSC. High temperature DTA provides a viable alternative for evaluating those materials. Evaluation of the beta transus temperature in titanium alloys is a typical example.


## INTRODUCTION

Titanium alloys are widely used in many industries due to an abundant resource base, high strength potential, good corrosion resistance and low density compared to other alloys. In the aircraft industry, for example, titanium alloy forgings are used in aircraft structures and engines. Other areas of application include aerospace and marine vehicles as well as chemical processing equipment, where corrosion resistance is an important property in the choice of material to be used.

Titanium can exist in two forms, a close-packed hexagonal crystalline form (alpha form) and a body-centered cubic form (beta form). Titanium transforms from its alpha to beta forms at a temperature called the beta transus (1). The amount of alpha and/or beta form present in a specific titanium alloy depends on the other metals present, but also depends on the processing conditions used to prepare the alloy. Since the alloy's ultimate end-use properties depend predominantly on the amount of alpha and/or beta form present, suppliers of titanium alloys are obviously interested in rapidly determining the beta transus and understanding how it is affected by composition or processing changes.

Traditional methods of metallographically determining the beta transus include microscopic observation of phases present in heat treated and quenched alloys. This method, which can be time consuming and relatively subjective, relies on the assumption that the rapid cooling suppresses other additional phase transformations and that the structure of the quenched alloy represents the phase relationship of the heat treatment temperature. This may not be true for samples heated near the beta transus.

Studies at Special Metals Corporation (2) have shown that the beta transus can be rapidly determined by DTA, and that the DTA data correlates well with data obtained by metallographic techniques.

## EXPERIMENTAL

In high temperature DTA the sample and or inert reference material are placed in a pair of ceramic cups resting on the top of insulated thermocouple pedestals. These thermocouples measure the differential temperature ($\Delta T$) which develops as the reference and sample are heated. When transitions occur in the sample, for example the beta transus, a large $\Delta T$ develops and is measured. In the experiments with titanium alloys, about 50mg of alloy was evaluated under an argon purge gas with aluminum oxide as the reference material. The materials were cycled (heated and cooled) at 10°C/minute between 500 and 1100°C.

## RESULTS

Figure 1 shows the heating and cooling curves for a typical titanium alloy. The beta transus is indicated by the endotherm (during heating) and exotherm (during cooling) in the region between 800 and 1000°C. The onset of the cooling peak provides the most reproducible point for comparing materials. The alloy (Figure 1) exhibits a higher beta transus temperature than unalloyed titanium (Figure 2). This shift indicates the primary added alloying element (aluminum) stabilizes the alpha structure. Other alloying elements such as chromium and iron, on the other hand, usually stablize the beta structure due to solubility in the beta phase. Figure 3 illustrates that the onset of the DTA cooling peak correlates well with the data obtained from conventional metallographic studies.

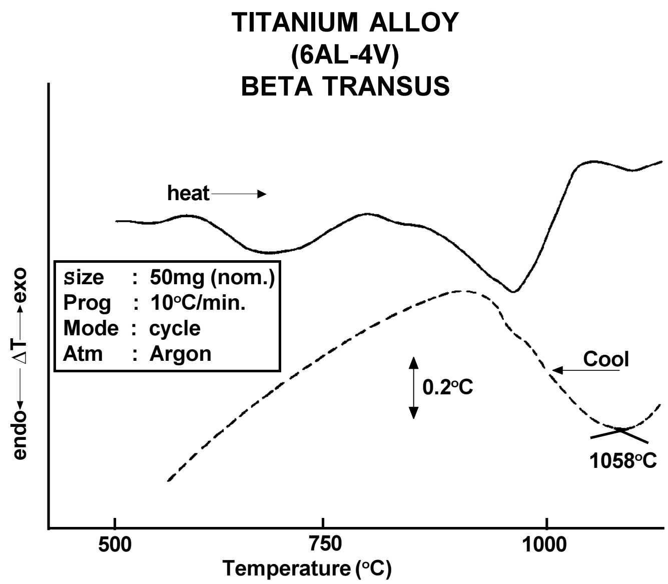


Figure 1

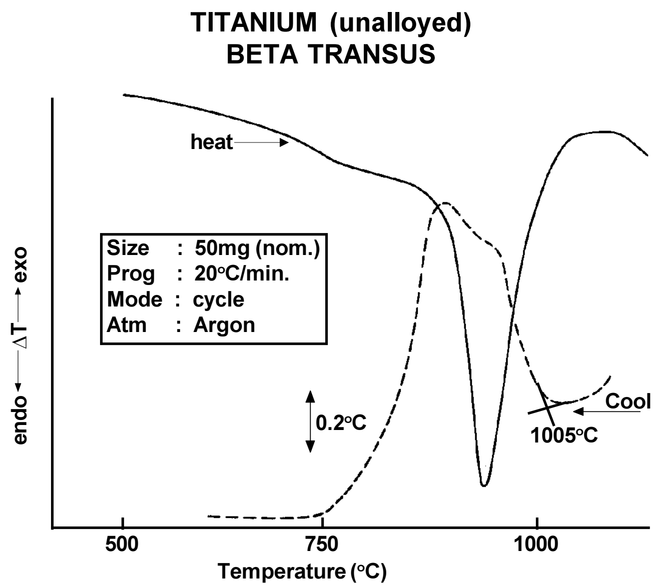


Figure 2

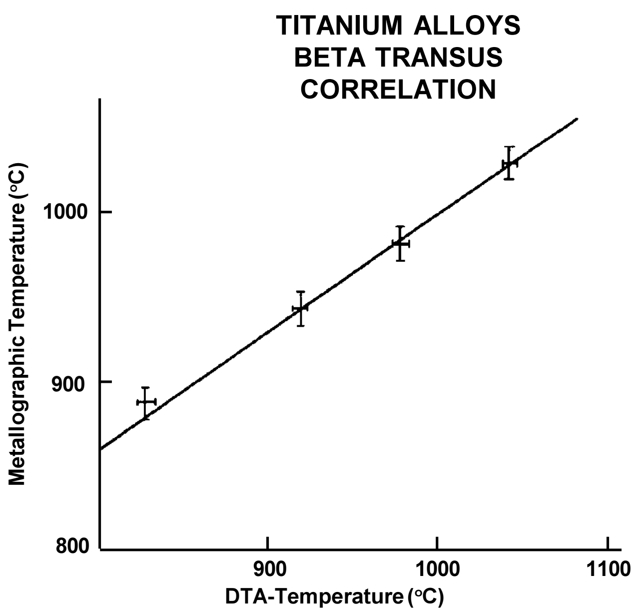


Figure 3

## REFERENCES


1. The Science, Technology and Applications of Titanium, R. I. Jaffie & N. E. Promisel (Eds), Pergammon Press, New York, 1966.
2. Claudia Burton, Special Metals Corporation, New Hartford, NY, Personal communication.



For more information or to place an order, contact:

**TA Instruments, Inc.**, 109 Lukens Drive, New Castle, DE 19720, Telephone: (302) 427-4000, Fax: (302) 427-4001
**TA Instruments S.A.R.L.**, Paris, France, Telephone: 33-1-30489460, Fax: 33-1-30489451
**TA Instruments N.V./S.A.**, Gent, Belgium, Telephone: 32-9-220-79-89, Fax: 32-9-220-83-21
**TA Instruments GmbH**, Alzenau, Germany, Telephone: 49-6023-30044, Fax: 49-6023-30823
**TA Instruments, Ltd.**, Leatherhead, England, Telephone: 44-1-372-360363, Fax: 44-1-372-360135
**TA Instruments Japan K.K.**, Tokyo, Japan, Telephone: 813-5434-2771, Fax: 813-5434-2770

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