THE EFFECTS OF CONCENTRATION
AND HEATING OR COOLING RATE
ON THE DTA CURVES OF Al–Ce ALLOYS*

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(Received November 30, 1976)

The crystallization of Al–Ce alloys was studied by DTA. The melting and freezing
DTA curves of the investigated alloys exhibit two peaks, corresponding to the trans-
formations of a high-purity phase and the eutectic phase, respectively. The peaks could
be separated during both freezing and melting by changing the heating or cooling rate.
The final temperature of the phase transformation is marked by the starting tempera-
ture of the second peak. A slight shoulder on the DTA peak, even on the opposite side
to the maximum point, may correspond to the final temperature.
The connection between the reaction time and the peak temperature for the sample
was studied at different cooling and heating rates.
It was concluded that a knowledge of the structure and composition of the studied
system is necessary in the interpretation of the DTA curves.

The properties of metals are mainly influenced by the crystallization process.
The crystallization is determined by the composition of the alloy and the rate of
solidification. In other words, it is of great importance how the metal passes
through the solid-liquid region.
Technological processes occur far from the equilibrium state, and technical
materials contain several alloying elements and impurities. Therefore, the data
available in the literature do not cover the technical demands. For practical pur-
pose further investigations are necessary.
In order to determine the conditions of solidification, we have applied thermal
analysis. We were mainly interested in the liquidus and solidus temperatures and
in the time for which the material stays between these temperatures.
In order to start with the simplest system, aluminium of high purity and Al–Ce
alloys were studied. Ce, as alloying element, is suitable for thermal cycling, since
its melting temperature is much higher than that of aluminium. That is, the Ce
concentration remains constant during the melting and freezing cycles. Further-
more, the application of rare-earth metals as addition elements is an up-to-date
problem. It is already known that the eutectic concentration is at 10% Ce; the
liquidus temperature changes by 10° up to that concentration. A solid solution
forms only at very low concentrations (lower than 0.05% Ce), and is not detectable
by thermal analysis.

* Paper presented at the Scientific Session on Thermal Analysis held at Balatonfüred,
Hungary, on 14–16 October, 1976.
Experimental

The effects of Ce concentrations between 0 and 13\% and of heating and cooling rates between 1.5 and 0.2°/min were studied. Differential thermal analysis was carried out in an air atmosphere, using a Mettler thermal analyser. A platinum-rhodium thermocouple (DTA 21) and an Al₂O₃ microcrucible were applied. The mass of the sample was approximately 100 mg. Samples were taken from an as-cast bar and turned to a shape identical with that of the microcrucible.

In interpreting the thermal curves, we faced the problem of the correct determination of the starting and final temperatures of the phase transformation. It was recently reported by Willmann [1] that the temperature determined in accordance with the ICTA proposal (extrapolated onset, \( T_{on} \)) differs from the true value, i.e. from the temperature determined by the point where the DTA curve departs from the base line for the first time (departure, \( T_{dep} \)).

Results

The melting and freezing DTA curves of the investigated alloys exhibit two peaks (Fig. 1).

Metallurgists have already established that the last step in the solidification of metals is the solidification of eutectic melt enclosed by the growing solid phase. Assuming that the second peak corresponds to the solidification of this eutectic phase (which may be characterized by isothermal phase transformation), we performed stepwise cooling (Fig. 2).

![Fig. 1. Characteristic DTA curve for the investigated alloy](J. Thermal Anal. 11, 1977)