APPLICATION **NOTE**

Alloys – Laser Flash Analysis

Thermophysical Characterization of a Neodymium Alloy

Dorothea Stobitzer und Fabia Beckstein, Applications Laboratory Selb, and Jeong Kwanhoon, Applications Laboratory Korea

Introduction

Neodymium alloys are key materials for modern high-performance applications. In particular, they are used as a basis for high-performance permanent magnets in electric motors, generators, wind turbines, sensors and hard drives. Along with the magnetic properties, the thermophysical characteristics of neodymium alloys also play a decisive role. At high power densities and rising operating temperatures, the thermal diffusivity, specific heat capacity and thermal conductivity have significant influence on the thermal behaviour of a material. These properties are essential for efficient thermal management, avoiding local overheating and ensuring long-term material and functional stability.

Knowledge of thermal diffusivity is of particular importance here, as it describes how quickly a temperature change propagates within the material. In combination with the density and specific heat capacity, the thermal conductivity can be determined from this – a central parameter for designing thermally loaded components.

Method and Measurement Conditions

The thermophysical properties of the neodymium alloy were determined with the LFA 717 *HyperFlash*® HT. Laser flash analysis is one of the most well-established methods for measuring thermal conductivity, is characterized by high precision and short measurement times. During the measurement, the front surface of the sample is excited by a short energy pulse, and the resulting temperature increase on the back surface is recorded without being in contact with an infrared detector. Based on a mathematical curve fit, the thermal diffusivity is determined from the measured signal.

In addition to the thermal diffusivity, the specific heat capacity was also determined by LFA according to the comparison method. For this purpose, a copper reference with known thermophysical properties was used. On the basis of the thermal diffusivity, specific heat capacity and density, the thermal conductivity was then calculated. The exact measurement conditions can be found in Table 1.

Table 1 Measurement conditions

Material	Neodym alloy
Sample carrier	Ø 8 mm , SiC
Temperature program	RT to 800°C; 50 K intervals
Sample dimensions	Ø 8 mm , thickness: 2.8 mm
Coating	Graphite
Reference for c_p	Pure Cu
Atmosphere	Argon
Heating rate	10 K/min
Pulse energy	250 V / 600 µs

NGB · Application Note 461 · EN · 0726 · Technical specifcations are subject to change.

NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb · Germany
Phone: +49 9287/881-0 · Fax: +49 9287/881505
at@netzsch.com · www.netzsch.com

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Results and Discussion

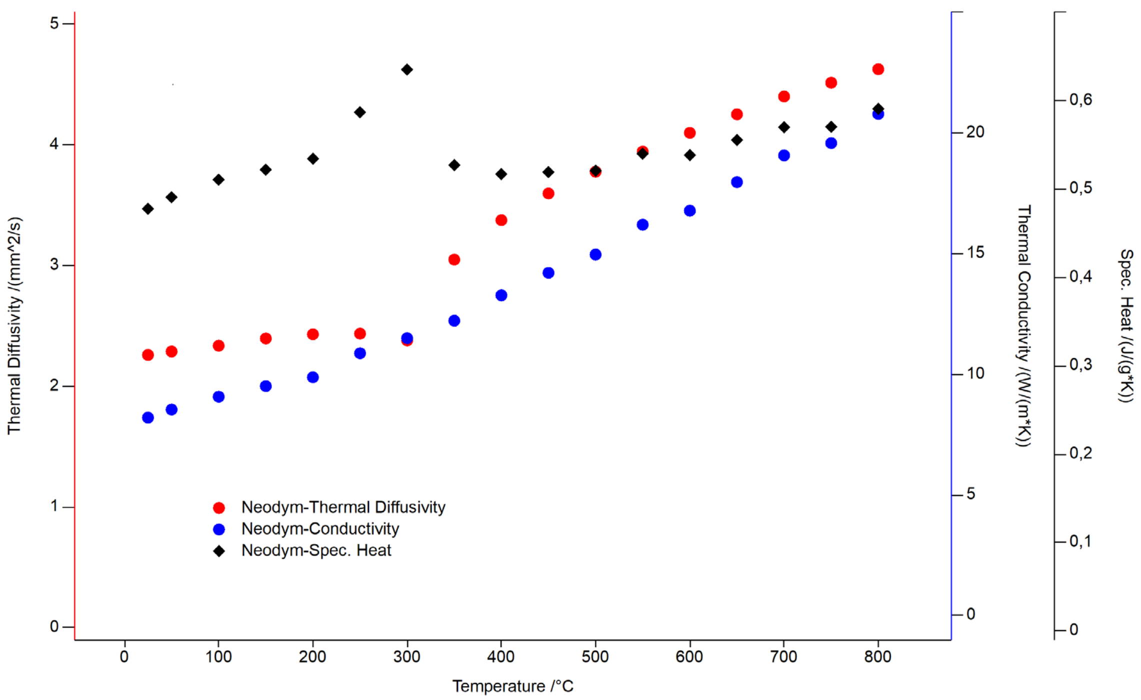
Figure 1 shows the thermal diffusivity, specific heat capacity and thermal conductivity of the investigated neodymium alloy from RT to 800°C. As the temperature rises, all thermophysical characteristics tend to increase. In the range of about 300°C to 350°C, however, the specific heat capacity shows a clear maximum, while the thermal diffusivity forms a local minimum at the same time. This correlated behaviour indicates a transition that is related to the Curie transformation of the alloy. Both properties are sensitive to structural or magnetic changes in the material and allow for clear identification of the relevant temperature range.

The calculated thermal conductivity, however, does not show a pronounced transition peak, but increases almost continuously over the entire measuring range. This behaviour is due to the fact that the opposing effects of the increased specific heat capacity and the reduced thermal diffusivity largely compensate for each other in calculating the thermal conductivity. The influence of the transition is therefore much less pronounced in the thermal conductivity than in the directly measured individual parameters.

The results show that the combined determination of the thermal diffusivity and specific heat capacity using LFA, the thermophysical behaviour of materials can be assessed more accurately. In particular, temperature-dependent anomalies, such as those that can occur close to the Curie transformation, can be reliably detected and interpreted on the basis of the individual parameters.

Summary

The LFA 717 *HyperFlash*® HT enables precise characterization of the thermal properties at high temperatures, especially through the non-contact laser flash method for determining thermal diffusivity. In combination with reference samples and density determination, the specific heat capacity and thermal conductivity can also be reliably determined.



1 Thermophysical properties of a neodymium alloy.

NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb · Germany
Phone: +49 9287/881-0 · Fax: +49 9287/881505
at@netzsch.com · www.netzsch.com