APPLICATION**NOTE**

Alloys – Dilatometry

Dilatometer Measurement on Thin Invar® Alloy

Liu Shaobo, Applications Laboratory Shanghai, and Doreen Rapp, Applications Laboratory Selb

Introduction

Invar® alloy, also known as Invar® or generically as FeNi36, is an iron-nickel alloy with a nickel content of 35.4% and a very low coefficient of thermal expansion at room temperature (between -20°C and 20°C, with an average value of around $1.6 \cdot 10^{-6}$/K). It is an indispensable structural material for precision instruments and devices.

Due to the excellent properties of Invar® alloys, they are used in various fields, such as gauges, large telescopes, ray tube gun parts, core wires of long-distance cables, glass sealing materials, ultra-thin Invar® alloy plates, thermostats, optical measuring systems and waveguides, LNG ship tanks, LNG ship components, pump towers, power electronics, aerospace parts, ship components and so on.

The most important characteristic of Invar® is its low coefficient of expansion. To accommodate various application environments, Invar® is fabricated into different shapes. While testing regular cylindrical samples is straightforward, testing film samples presents unique challenges.

How Can We Effectively Test These Film Samples?

In this application note, we present one of our dilatometers that enables the determination of very small thermal expansion coefficients and also explain how measurements are carried out on Invar® films.

Thin Film Invar® Alloy Background

In the screen production and manufacturing process, the vacuum evaporation process is the core link that distinguishes OLED screens from LCD. The metal mask plate is a crucial consumable in the OLED evaporation process. Due to the nature of the OLED production process, metal masks experience significant wear and tear, necessitating regular replacement. This replacement is a key factor in the overall production costs of OLEDs.

At present, the metal mask used in AMOLED products mainly consists of two parts – an open mask plate (Coarse Metal Mask, CMM) and a fine metal mask plate (Fine Metal Mask, FMM). CMM is primarily used for the evaporation of metal materials, while FMM, a high-precision metal mask, is mainly used for the evaporation of organic light-emitting materials. Industry insiders estimate that the annual demand for CMM and FMM in China alone exceeds 1 billion euros.

CMMs are made of Invar®36 material with a thickness of 40 µm to 200 µm and are mainly used for the vapor deposition of permeable and conductive materials in chambers for vapor deposition.

FMMs are made of Invar®36 material with a thickness of 20 µm to 30 µm and are mainly used for vapor deposition of OLED materials in chambers for vapor deposition.

NGB · Application Note 334 · EN · 1124 · Technical specifications 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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Thermal Expansion Measurement Equipment

The measurement was carried out with the DIL 402 *Expedis® Supreme*. The dilatomter was equipped with a steel furnace and an SiO_2 sample hoder; depicted in figure 1.

Measurement Principle

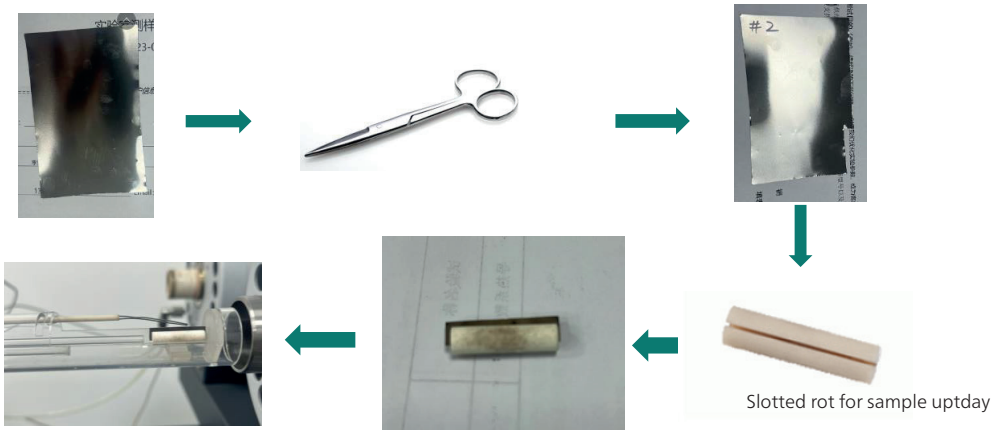
The sample undergoes a specific temperature procedure, during which a static load is applied. The dimension of the sample in the test direction is then measured in relation to temperature or time.

Measurement Conditions and Sample Preparation

The sample was heated from RT to 300°C at a heating rate of 5 K/min in an argon atmosphere. For the measurement, the sample was placed in a slotted rod made of Al_2O_3.

The sample was a thin sheet of Invar® 36 with a thickness of 25 µm. The specimen used for the measurement had a length of 24.6 mm and a width of 6 mm. The tools for sample preparation are presented in figure 2.

1 DIL 402 *Expedis® Supreme*



2 Sample preparation tools, employed for this test.

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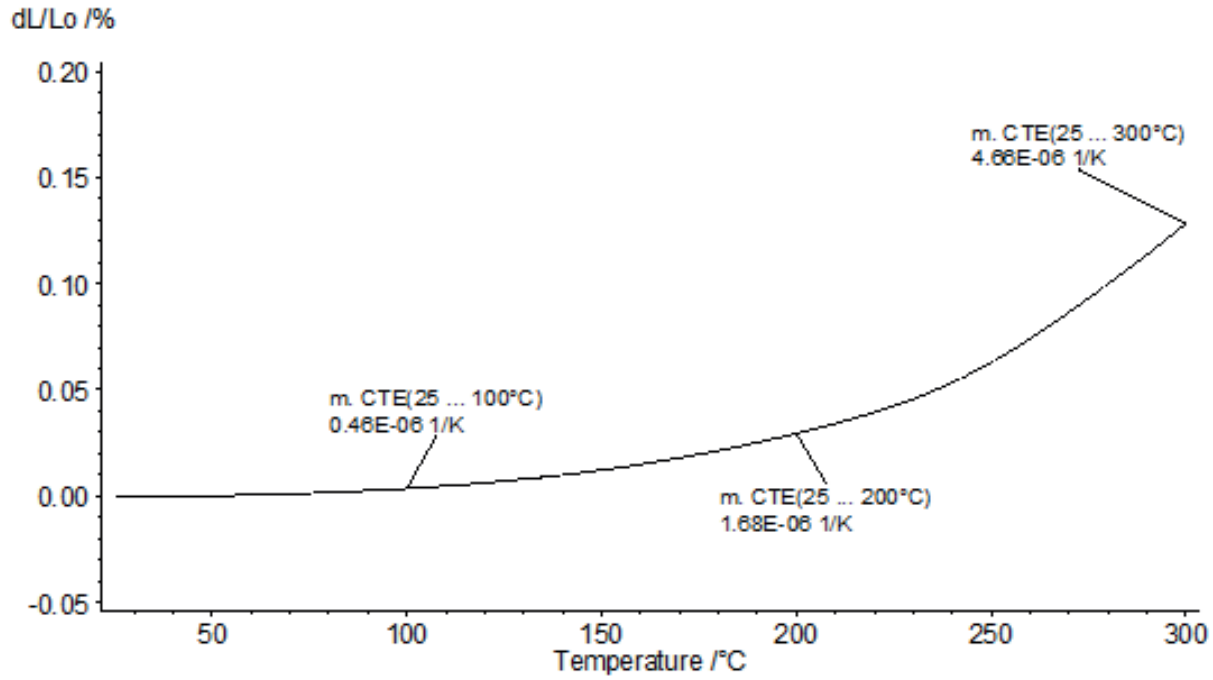
Measurement Results

The thermal expansion of the Invar® sample is displayed in figure 3. In addition, values for the mean coefficient of thermal expansion (mCTE) were calculated for the temperature ranges 25°C to 100°C, 25°C to 200°C and 25°C to 300°C. In the temperature range up to 200°C, the sample exhibits the low mCTE values that are expected for Invar.® At higher temperatures, the mCTE increases as the anomalous behavior of Invar diminishes.

Summary

The thermal expansion of an Invar® film sample was measured with the DIL 402 *Expedis® Supreme*. As support for the thin sample, a slotted rod made of Al_2O_3 was used. The results demonstrate the low coefficient of thermal expansion that makes Invar® unique. Additionally, they highlight the high sensitivity of the DIL 402 *Expedis® Supreme*, which enables the precise measurement of such low-expansion materials.



3 Thermal expansion of an Invar® film from RT to 300°C

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