Thermal Expansion Measurements between -180 and 500 °C using the Low-Temperature Dilatometer DIL 402 C

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1. Introduction

Over the past few years, industry has increased its efforts to introduce new materials for high performance applications. For example, glass ceramics or fiber reinforced polymers are often used for the production of modern terrestrial telescopes, aircrafts (Figure 1) or satellites. In many cases accurate knowledge of the thermal expansion is of paramount importance for the application of the new materials. Measurements are necessary in the temperature range of interest to overcome any problems regarding e. g. formation of tensions between two different materials in contact.

Figure 1: Airbus A-340-300 (Photo: Airbus Industry, Lufthansa)

The low-temperature version of the NETZSCH DIL 402 C allows measurements of the thermal expansion between -180 and 500°C with outstanding performance. The vacuum-tight design allows testing under defined atmospheres. Evacuation and backfilling with inert atmospheres removes any influences from humidity. A completely thermostated housing around the Vacodil (Invar) high resolution inductive transducer system (1.25 nm/digit) reduces system drift. Therefore, measurements are possible with unmatched reproducibility (Figure 2) and accuracy.

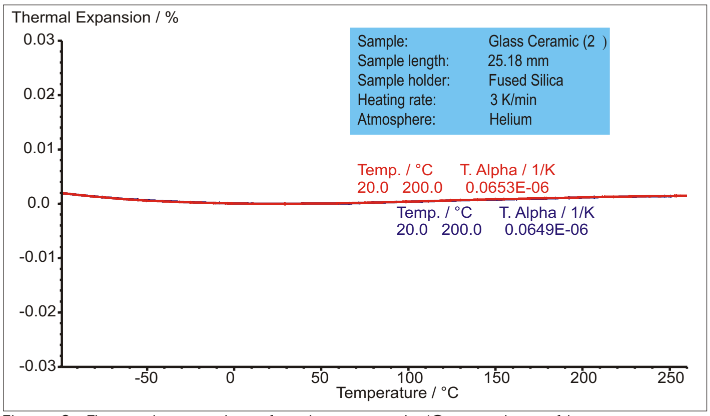

Figure 2: Thermal expansion of a glass ceramic (Comparison of two measurements on the same sample).

2. Application examples

Depicted in figure 3 is the thermal expansion of Zerodur between -150 and 100°C. Zerodur is often used as mirror carrier in terrestrial telescopes. Two runs were carried out on the same sample. The reproducibility of the coefficient of thermal expansion between 0 and 50°C was $0.3 \cdot 10^{-9}$ 1/K. The coefficient of thermal expansion was in good agreement with the manufacturer's values (Schott Glasses, Mainz).

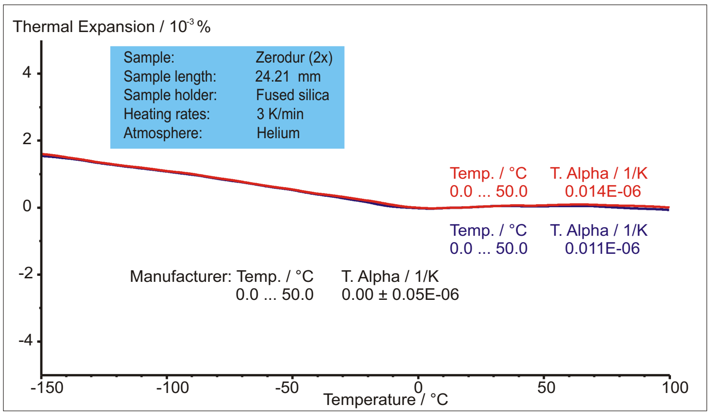

Figure 3: Thermal expansion of Zerodur (Schott Glasses Mainz) between -150 and 100°C

Depicted in figure 4 is the thermal expansion of 3 different carbon fiber reinforced polymer samples (Two-dimensional fiber reinforcement). Such materials are used, for example, in the production of the wings of modern aircraft (figure 1). Changing the fiber orientation, a different coefficient of thermal expansion was obtained. Knowledge of the dependency yields fruitful infomation about the optimum fiber orientation for the later application.

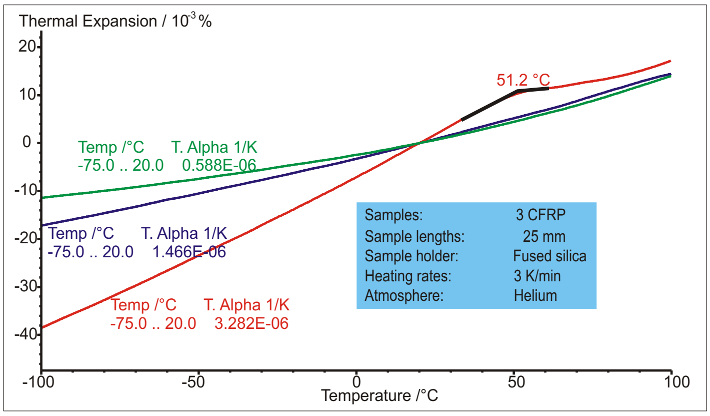

Figure 4: Thermal expansion of three carbon fiber reinforced polymer samples (same matrix material, different fiber orientation)

The thermal expansion in and perpendicular to the reinforcement direction of a CFR-polmer (red curve in figure 4) is presented in figure 5. Differences can be seen in the expansion behavior. Perpendicular to the reinforcement direction (green line) the influence of the fibers on the thermal expansion is small. Therefore, the sample shows a behavior typical for the polymer matrix.

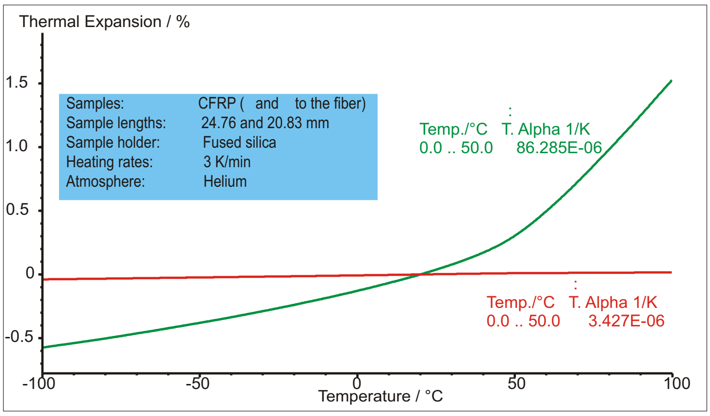

Figure 5: Thermal expansion of a carbon fiber reinforced polymer sample in and perpendicular to the fiber direction.