DIMENSIONAL EFFECTS IN THE THERMAL EXPANSION OF CARBON FIBER REINFORCED PLASTIC AT LOW TEMPERATURES

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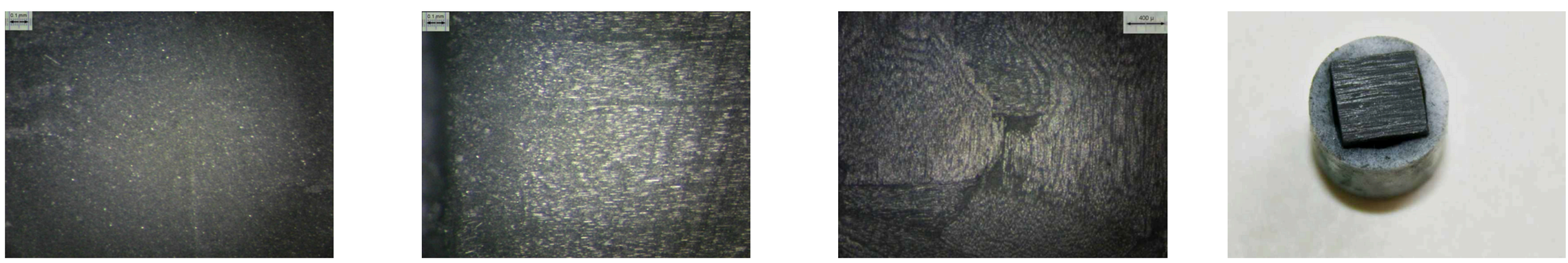
ABSTRACT

Thermal expansion behavior of carbon fiber-reinforced composite plastics (matrix: commercial carbon fiber TS36S, binder: EDT-10P) and composite plastics with a braided base was studied in the temperature range of 160-293 K using high-sensitivity capacitive dilatometry. Over the entire temperature range, the thermal expansion of the composite materials is anisotropic, with thermal expansion coefficients measured along and perpendicular to the fiber direction differing by two orders of magnitude in absolute value and showing opposite signs.
The negative thermal expansion along the fiber direction is likely due to the transverse thermal vibrations of the two-dimensional carbon planes that form the fiber structure.

EXPERIMENTAL METHODOLOGY AND STUDIED SAMPLES

In this work, the thermal expansion of carbon fiber-reinforced plastic was investigated using high-sensitivity capacitive dilatometry. Measurements were performed with a capacitive low-temperature dilatometer, specifically modified for the study of nanostructured materials. Calibration was conducted prior to each measurement series, utilizing a reference sample of ultra-pure copper (99.999% purity). The maximum sensitivity of the dilatometer was 2.6×10^{-10}cm/Hz, with a resolution of 2×10^{-9}cm.



a) b) c) d)

Fig. 1. Pictures of the top surface of the samples for measuring the thermal expansion of composite samples: a) perpendicular to the fiber direction; b) along the fiber direction; c) sample with woven fibers; d) sample prepared for thermal expansion measurements.

RESULTS AND DISCUSSION

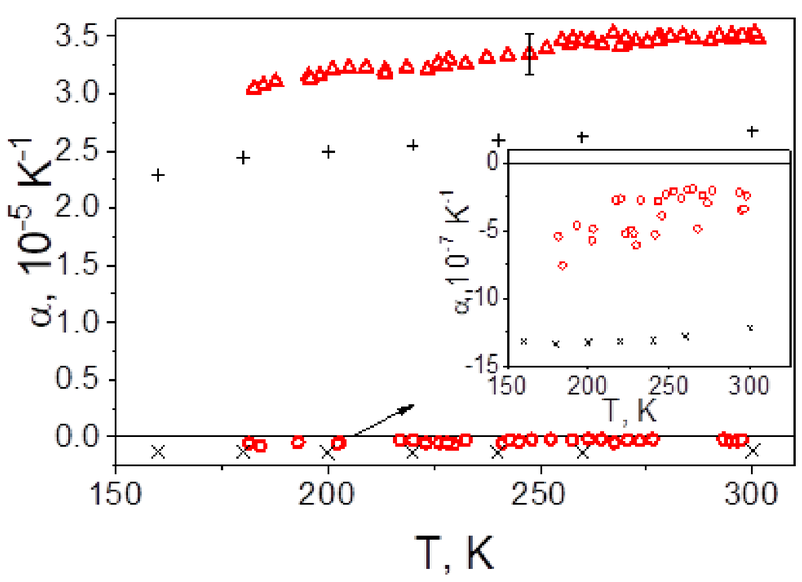


Fig. 2 Temperature dependence of the linear coefficient of thermal expansion (LTEC) for the unidirectional carbon fiber-reinforced composite plastic (TC-36S) sample (Δ – along the carbon fibers, ○ – perpendicular to the carbon fibers). For comparison, the LTEC of graphite is also shown (× – along the basal planes; + – perpendicular to the basal planes).

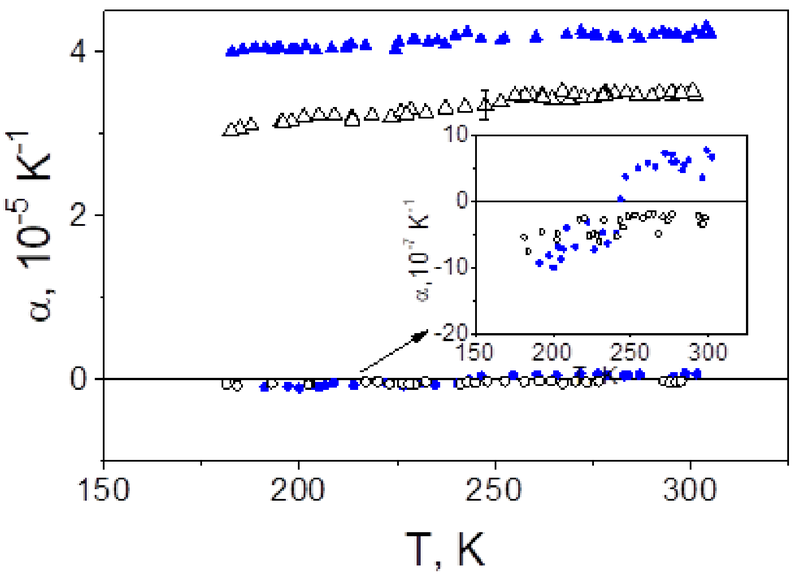


Fig. 3 Temperature dependence of the LTEC for the unidirectional carbon fiber-reinforced composite plastic (Δ – along the carbon fibers, ○ – perpendicular to the carbon fibers) and the sample with a woven carbon fiber base (▲ – along the carbon fibers, ● – perpendicular to the carbon fibers).

CONCLUSIONS

The thermal expansion of unidirectional carbon fiber-reinforced composite plastic (matrix – TC36S carbon fibers, binder – EDT-10P) and composite plastic with a woven carbon fiber base was studied using high-sensitivity capacitive dilatometry in the temperature range of 160–293 K. Throughout the entire temperature range studied, the thermal expansion of the composite plastic was anisotropic, with LTEC values along and perpendicular to the carbon fiber direction having opposite signs. The negative thermal expansion values along the fiber direction are most likely due to transverse thermal vibrations of the two-dimensional carbon planes that make up the fiber structure.

ACKNOWLEDGMENTS

The authors are most grateful to National Academy of Sciences of Ukraine for the partial financial support of this research within the scope of Grants No. 0122U001504 and No. 2H/52-25.