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DIMENSIONAL STABILITY INVESTIGATION OF LOW CTE MATERIALS AT TEMPERATURES FROM 140 K TO 250 K USING A HETERODYNE INTERFEROMETER

Abstract

Light weight materials with excellent dimensional stability are increasingly needed in space based applications such as telescopes, optical benches, and optical resonators. Glass-ceramics and composite materials can be tuned to reach very low coefficient of thermal expansion (CTE) at certain temperatures, including room temperature and cryogenics, where a growing number of instruments in scientific and earth observation space missions are operated. Very accurate setups are needed to determine the CTE of such materials. With our laser-interferometric dilatometer setup we are able to measure CTEs of a large variety of materials in the temperature range of 140 K to 250 K. Special mirror mounts with a thermally compensating design enable measurements of the expansion of cylindrical tube-shaped samples using a heterodyne interferometer with demonstrated noise levels in the order of 10 $\mathrm{pm}/\sqrt{\mathrm{Hz}}$. The temperature variation of the sample is obtained by a two stage controlled heating/cooling setup where a pulse tube cooler and electric heaters apply small amplitude temperature signals to cool/heat the sample radiatively in order to reach a homogeneous temperature over the whole sample. A carbon fiber reinforced polymer (CFRP) sample was selected to run CTE measurements, achieving results in the 10^{-8} K^{-1} range including all known uncertainties. The limitations of our setup have been identified and the largest uncertainty contribution has been determined to be tilt-to-length coupling of the sample due to temperature variations. Several improvements are currently underway to minimize our uncertainty budget. New results with the enhanced setup will be presented