VSL Picodrift Interferometer

Results of the working prototype Picodrift Interferometer
EMRP JRP IND13 Thermal Design and Dimensional Drift
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Measurements of samples with picometer uncertainty using the Picodrift interferometer

Accurate dynamic stability measurements are required for understanding and minimizing intrinsic noise present in materials and material connections, limiting the performance of high-end precision engineering and measurements equipment. The Picodrift interferometer has been designed to characterise and quantify the temporal stability of materials and connections. Additionally, the measurements can be used to correlate dimensional instability to environmental changes or externally induced effects, allowing for a decomposition of the noise in terms of dependencies. Hence, homogeneous but also composite or hybrid materials can be characterised, as well as a wide range of joints between (different) materials can be analysed and optimised for use in the end-product. The instrument proofs particularly well suited for measuring and calibrating actuators, and potentially also sensors. In this document the constraints are limitations of the instrument are discussed. If the presented considerations are taken into account, the instrument is able to measure displacements in the picometer range. For short term stability measurements (seconds) the limiting measurement rms noise is approximately 5 pm, while for medium term measurements (hours) with stable weather conditions, the limiting measurement rms noise is approximately 30 pm. For displacement measurements of actuated samples, the measurement resolution is well below the 5 pm.

Figure 1. Picodrift interferometer with, in the center between the two main polarising beam-splitters, the sample and refractometer cell holder.

Since the instrument is limited in its performance by any asymmetry between sample and reference sub-interferometer, it is essential to minimise or account for these asymmetries. As the alignment of the interferometer is never perfect, a sample measurement should always be preceded by a null-measurement of the empty interferometers to be able to account for the initial path length difference between both sub-interferometers. Next the refractometer interferometer should be matched to that of the sample interferometer with respect to optical path length and environment dependence. Afterwards, a period of acclimatisation is required to minimize temperature gradients, where the duration of this period is matched to the anticipated measurement duration, thermal properties of the sample, and correlation of environmental effects to the anticipated instability measurements. For longer durations of measurements, large pressure variations can influence the exact position of the beam-splitters, resulting in step-changes in the performance and required corrections of the interferometer, consequently a correlation of the monitored pressure and any observed effect should always be performed. Ultimately, it is essential to have an excellent polarisation purity, which can be enforced by adding additional polarisers in front of the detector, or even in the unused arm, parallel to the sample and refractometer cell, of the interferometers.

The sample to be measured has to satisfy some requirements for a successful measurement with the Picodrift interferometer, see Figure 2 for examples. The dimensions are in principle relatively free to be chosen, but for the standard configuration the length should matched with that of the refractometer cell and ideally be equal or less than 100 mm, the width and height should be equal or less than 40 mm. To prevent any influence of the mounting on the measurement, the sample should be placed such that it can move freely, and is not affected by any strains or stresses. The end facets of the sample should be parallel (better than 3 arcmin) and reflective. The material properties should be known to allow for a correction of expansion or compression effects due to temperature and pressure. Also the nominal length of the sample should be known in order to be able to compensate for environmental changes. Finally, the environmental parameters of the sample should be monitored, especially in case temperature gradients are likely to be present. If the measurement object is actively controlled, the heat production should be minimised and an active temperature control can be considered.

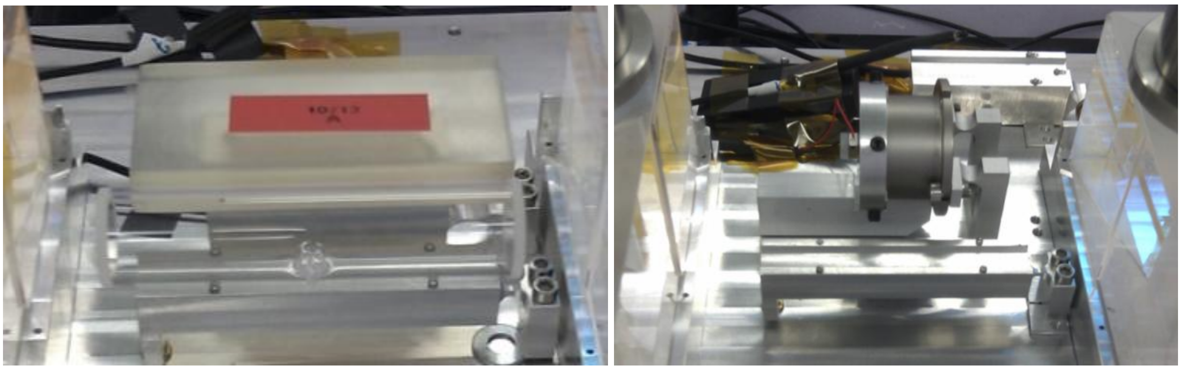

Figure 2. Examples of measurement objects, consisting of a ClearCeram gauge block (left) and a piezo actuator connected to a retroreflector (right).