TEMPERATURE CALIBRATION OF MODULATED PHOTOTHERMAL RADIOMETRY APPARATUS

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The modulated photothermal radiometry technique (MPTR) is a well suitable method for the thermal conductivity measurement of materials deposited as thin film (from few nanometers to few micrometers thick). The measurement principle consists in measuring the phase lag between a periodic thermal excitation applied on the front face of the tested specimen (composed by a thin film deposited on a known substrate) and the periodic component of the induced temperature response of the same face. A metrological facility based on MPTR technique has been designed at LNE in the framework of a collaboration with I2M institute for the thermal conductivity measurement of thin films over a wide temperature range (up to 1000 °C). This metrological tool should enable to perform thermal conductivity measurements that are directly traceable to the international system of units (SI), with the objective to improve the reliability and accuracy of this type of measurement at sub-micrometer scale.

As thermal conductivity depends on temperature, it is essential to determine accurately the temperature to be assigned to the value of the thermal conductivity measured. During the measurement process, the specimen is first heated by an oven at a constant temperature (between 23 °C and 1000 °C), which is considered to be the temperature of the test, then it is submitted to a thermal excitation produced by a modulated laser beam. The temperature of the test is measured by a thermocouple located in the oven in the vicinity of the specimen. This temperature value is unavoidably different from the actual temperature of the thin film, due to the inhomogeneity of the oven, the errors of the temperature measuring chain and the local temperature increase of the thin film generated by the thermal excitation. This last factor depends on the power of the modulated laser beam.

An in situ calibration method inspired from calorimetric techniques, and based on the use of the melting of reference materials of pure metals defining the fixed points of the international temperature scale of 1990 (ITS90), has been developed by LNE and I2M institute in order to calibrate the MPTR facilities in temperature. In addition, an improved measurement procedure, which takes into account the influence of the power of the thermal excitation on the temperature of test, is also investigated. This procedure should enable to determine intrinsic thermal conductivities of thin films, regardless of the measurement conditions. This paper presents a detailed description of the temperature calibration method as well as the procedure under development for the intrinsic thermal conductivity measurement.

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