Thermal expansion and magnetostriction measurements

An application using Oxford Instruments Superconductivity's HelioxVL, advanced sorption single shot ^{3}He refrigerator

The samples available for such measurements are frequently of the order of 1 mm^3 only. By using tilted capacitor plates the new sensor can measure samples with an active length of less than 1 mm, with an absolute resolution of about 1 Å. The dilatometer (Figure 1) is designed to fit into a variable temperature insert with a 50 mm bore or less. For low temperature measurements between 300 mK and 4 K an Oxford Instruments Superconductivity HelioxVL ^{3}He insert is used.

Dr Rotter and his colleagues (Figure 2) used the tilted plate method to overcome some of the problems associated with parallel plates. The capacitance method is one of the most sensitive methods for measuring small length changes of solids and has the advantage, compared with specific heat measurements, of covering a large temperature range with one instrument. Capacitive cells with parallel plates are easy to calibrate, but they are either large, causing problems with thermal stability, or present difficulties with sample handling. Even if the problem of thermal stability can be overcome, the limited space available in the magnetic coil causes problems, particularly when magnetostriction has to be measured both parallel and perpendicular to the field.

Tilted plates, with the sample placed in a hole in the lower capacitance plate, enabled the cell size to be minimised. The tilted plate construction gives good sensitivity with a sensor diameter of only 22 mm and a height of 14 mm (Figure 3). Careful design has provided a high dynamic measurement range, minimised the temperature dependence of the zero signal, ensured excellent thermal quilibrium, and prevented any possibility of the capacitor plates touching. Mechanical fixing of the sample, using Cu-Be springs, enables the stress on the sample to be adjusted to a known value, and the absence of glue, for fixing or insulation, eliminates any associated capacitance drift. The use of silver for essential parts of the dilatometer halves the

Figure 1: Miniature Capacitance Dilatometer

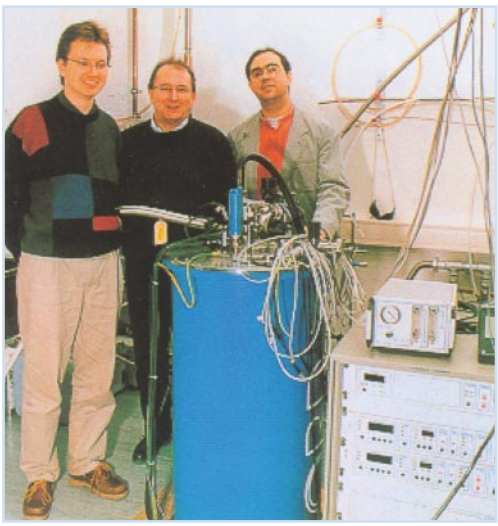

Figure 2: Dr Martin Rotter, Prof Michael Loewenhaupt, Dr Mathias Doerr

Dr Martin Rotter and colleagues at the University of Technology, Dresden and the Technical University, Vienna, have successfully developed a very small capacitive sensor (Figure 1) for measuring thermal expansion and magnetostriction of small and irregular shaped samples[1]. The sensor can measure a range of sample lengths over a wide range of temperatures from 0.3 K to 200 K and in high magnetic fields up to 15 Tesla. This opens up a number of possible applications, such as the investigation of crystal field effects on the magnetoelastic properties of single crystals and structural phase transitions.

References:

[1] M.Rotter, H.Müller, E.Gratz, M.Doerr, M. Loewenhaupt Rev. Sci. Instr. 692742 (1998)

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heat capacity compared to OFHC (oxygen free high conductivity) copper and eliminates nuclear heat capacity at low temperatures and high magnetic fields.

Although more difficult to calibrate than normal parallel plate dilatometers, Dr Rotter feels that the advantages and potential of the tilted plate sensor more than compensate for the extra effort required.

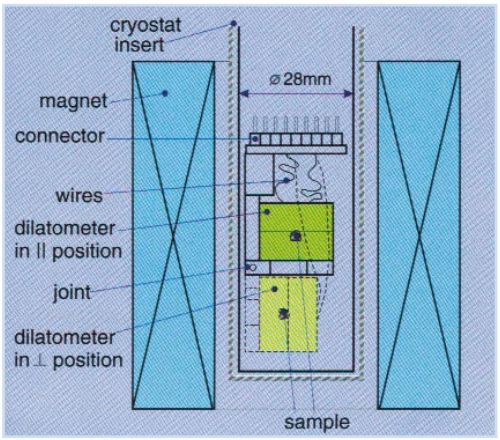

Figure 3: Arrangement of the dilatometer, temperature insert and magnet system. The full and dashed lines show the coil positions parallel and perpendicular to the magnetic field respectively.

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