The Torque Magnetometer

Principle of Operation

The torque magnetometer (TMM) is based on the principle that a magnetic field exerts a torque (force) on magnetic samples to try to align the magnetization with the field. Whenever the magnetization is pulled in a direction other than the easy axis, the anisotropy tries to pull the magnetization in the easy axis direction. The force with which this takes place can be measured. The torque can be measured in several different ways. A very easy way has been described by Cullity [1] in which a sample in a rod hanging on a torsion wire is positioned in a magnetic field. A torque is needed to twist the wire and hence the torque exerted on the sample is proportional to the angle of rotation of the sample. Presently a more expensive and accurate automated method is used in most laboratories. The measurement set-up used in this case is presented in *Figure 1*.

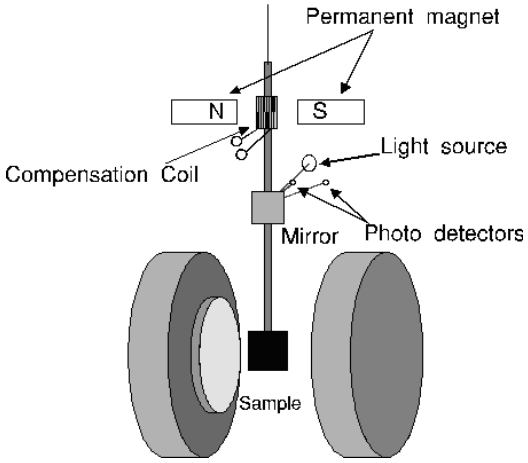

Figure 1 Schematical Torque Magnetometer set-up.

In the figure we see a sample holder with sample hanging on a thin wire in a magnetic field. Because of the field, the sample experiences a torque. At the top end of the sample holder, a coil is mounted between a permanent magnet of a known strength. The torque on the sample can now be compensated by a torque on the coil when a current flows through this compensation coil. Using a small mirror, a lamp and two photo diodes to detect the rotation of the sample, the current through the compensation coil is controlled. The current through the compensation coil is proportional to the torque exerted on the sample.

Because the super thin torsion wire is very fragile, **ADE Torque magnetometers use a different method**.

In an ADE TMM the torsion wire is replaced by a virtually frictionless air bearing. Because the performance of the TMM depends strongly on the quality of this air bearing, this is a very expensive component, but well worth it because in contrast with the torsion wire TMM, in an ADE system you can actually replace a sample easily without risking breaking the wire.

Torque magnetometers are mainly used for determining the anisotropy axis in a magnetic material. Measuring the anisotropy is done by changing the field direction with respect to the sample from -180° to 180° while measuring the torque. This is done for different values of the field in order to be able to make an extrapolation to infinite field. There are several ways of determining the anisotropy constants from the torque curves, such as using Fourier transformations.

Although the TMM is an extremely sensitive device - it can measure the torque produced by a mono layer of magnetic material - and it is very suitable for measuring torque curves, determining the anisotropy and the rotational hysteresis loss, it is not suited for any other type of measurements, the magnetization direction can only be calculated at saturation and therefore it can not be used as general measurement device without any other measurement systems.

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[1] B.D. Cullity, Introduction to Magnetic Materials, p. 217, fig. 7.10, Addison-Wesley, Reading MA, USA, (1972)