Application Note

Vector Measurements

Many magnetic materials have different magnetic properties depending on the direction in which they are measured. These materials are called anisotropic materials. Examples of such materials are virtually all modern data storage media such as hard disks, video tapes etc. but also for example the materials used in the making of read heads that are used in hard drives. In an anisotropic material, the magnetization has a tendency to align with the so-called anisotropy or “easy axis” direction, unless the magnetic field forces the magnetization to point in another direction. If one measures such a material with the field applied in a direction other than the easy axis, the magnetization vector will only align with the field when the field is strong enough to fully saturate the material.

Standard (scalar) VSM sense coils only measure the magnetization component in the direction of the applied field and will therefore not give the complete picture in many situations. Figure 1 below gives an illustration of this. This figure shows the hysteresis loop as it is presented in a standard scalar VSM.

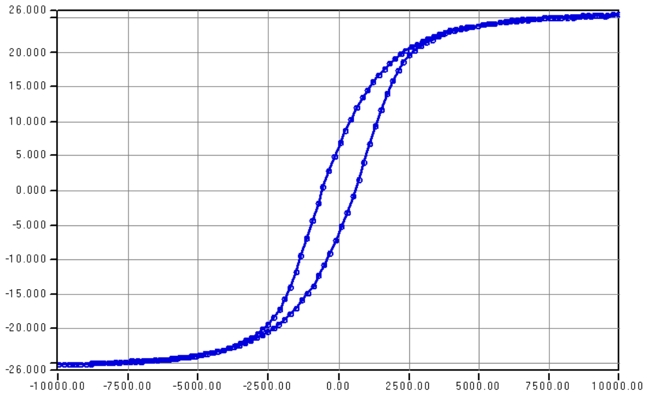


Figure 1 scalar measurement

In Figure 2, the same measurement is shown as it is presented in a vector VSM.

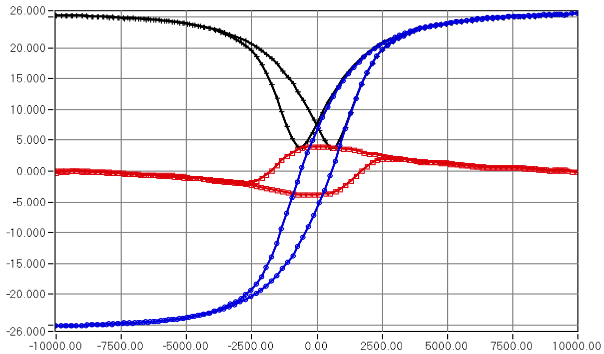


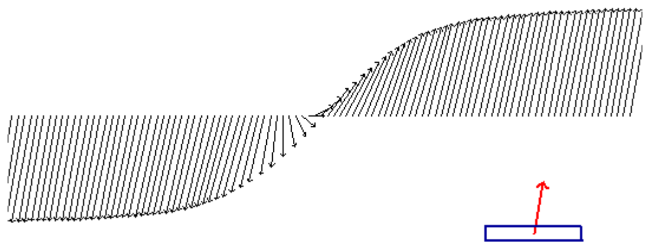
Figure 2 vector measurement. The blue curve = M_x, the red curve represents M_y, the black curve represents M_{total}.

Figure 2 shows the component of the magnetization parallel to the field, M_x and the component of the magnetization in the direction perpendicular to the field, M_y. From M_x and M_y, the total magnetization M_{total}can be calculated as the vector sum of M_x and M_y.

Another way of looking at this data is shown in figure 3 where the magnetization vector as a function of the magnetic field is plotted.

Figure 3: vector representation of measurement. The little box with the arrow indicates the direction of the field relative to the sample.

Vector coils allow one to detect signals perpendicular to the field, which greatly facilitates finding the easy axis and detection of many angular properties. The vector coils will also immediately indicate if you are not measuring exactly along the easy axis direction.



Torque Measurements

Torque magnetometers are widely used to measure magnetic anisotropy. A torque magnetometer gives a direct measurement of the force exerted on the sample by the externally applied field. From this force, the software will automatically determine the anisotropy.

MicroSense offers a torque option for most of their VSM systems. This torque option is an addition to an MicroSense VSM system. It consists of a very sensitive torque head and torque sensor, a rotation mechanism and torque electronics.

Alternatively, vector coils can be used to simulate a torque measurement. A torque simulation measurement with standard vector coils can give reasonable results, depending on the type of sample and the magnitude of the signal. However, a true torque magnetometer is typically 10 times more sensitive and many times more accurate than standard vector coils. Also the maximum field that can be reached using a torque magnetometer is higher than the maximum field with vector coils.

Model 10 VSM

For those customers for whom anisotropy studies are extremely important, MicroSense offers the Model 10 VSM, a VSM system that was designed from the ground up to optimize vector performance. Because of it's design, the vector accuracy of this system is up to 15 times higher than the accuracy of vector systems of any other commercial VSM system. This vector VSM is so sensitive and accurate that it is considered a good alternative to a VSM and a torque magnetometer combination. A robotized version of the model 10 VSM recently won the R&D 100 award.

Vector option for EV5, EV7, EV9 and EV11 VSM

While he Model 10 VSM comes standard with the worlds most accurate and sensitive vector sense coils, MicroSense offers a more conventional vector option for all their other VSM models. This vector option allows the operator to quickly replace the standard scalar coils with a set of vector sense coils. With these vector coils one can do any normal VSM measurement, with the added information provided by the Y signal. Alternatively, one can do a simulation of a torque measurement. This measurement is as good as or better than similar measurements done on other commercial vector VSMs but never quite as accurate as a torque measurement done on a MicroSense torque magnetometer or measurements done on the Model 10 VSM that was specifically designed for vector and torque measurements.

Specifications

	Maximum Field	Noise without averaging	Noise with 100 averages
EV7	1.75T	< 5 μemu (<2.5 μemu Typical)	< 1 μemu
EV9	2.15 T	< 5 μemu (<2.5 μemu Typical)	< 1 μemu
EV11	2.7 T	< 5 μemu (<2.5 μemu Typical)	< 1 μemu
Model 10	2.2 T (2.0 T for most accurate performance)	< 5 μemu (<2.5 μemu Typical)	< 0.5 μemu