CONSTRUCTION OF A VIBRATING SAMPLE MAGNETOMETER TO MEASURE MAGNETIZATION OF SOME FERROMAGNETIC MATERIALS

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The study of magnetic properties of materials is a basic requirement for understanding electronic behavior in condensed matter. Many verities of inorganic compounds and alloys of transition metals have been synthesized wherein the electrons show highly correlated behavior that means the conduction electrons depend on the presence or absence of neighboring electrons. These electronic correlations result in magnetism and superconductivity. This different type of behavior depends upon the strength of coulomb and exchange interactions among electrons. The studies of these interactions among electrons require magnetic measurement at low temperature and high magnetic fields.

Magnetic materials are classified into two broad categories, soft or hard. Soft magnetic materials are characterized by large permeability and very small coercivities, typically less than 1 Oe. Hard magnetic materials are most often used in permanent magnet applications, and are characterized by large saturation magnetizations, large coercivities, typically greater than 10 kOe, and also by large energy products (i.e., BH_{max}). Intermediate magnetic materials are generally characterized by coercivities on the order of 1 kOe, and these materials are usually used in magnetic media. Intermediate magnetic materials include; γ-Fe_2O_3, $Co_{80}Cr_{20}$, $Co_{77}Ni_{10}O_{13}$, and thin films. The characteristics of any magnetic material, whether it is hard, soft, or intermediate, are best described in terms of their hysteresis loop.

Many types of magnetometers have been developed and are now commercially available to determine the properties of magnetic materials. They have been extensively reviewed by English Scientist Foner and can be broadly classified in to two categories.

1) Those employing direct techniques, such as measurement of the force experienced by the specimen in a non-uniform field (Guoy, Faraday, Kahn balances)
2) Those based on indirect techniques such as measurements of magnetic induction due to relative motion the sample and the detection coils system (vibrating sample, vibrating coil, SQUIDs) or use of galvanomagnetic effects such as the Hall effect.

The most common measurement method employed for hysteresis loop determinations at ambient temperature is the Vibrating Sample Magnetometer (VSM). Vibrating Sample Magnetometer systems are used to measure the magnetic properties of materials as a function of magnetic field, temperature, and time. They are ideally suited for research and development, production testing, quality and process control. VMS, first developed by Foner in the late 1950s, is a basic research tool for determining magnetic properties in a variety of studies of the structure of paramagnetic, ferromagnetic, antiferromagnetic, diamagnetic and ferrimagnetic materials. VSM's have been used in such areas as the study of amorphous and magnetic bubble domain materials and investigations of the nature of the bonds in inter metallic components. Further uses have included the measurement of hysteresis loops of magnetic tape and disc materials and the rare earth cobalt compounds. In addition, the VSM is ideal for superconductivity measurements (Meissonier effect, diamagnetic shielding, and critical field determination) and the study of the magnetic properties of thin films or single crystals. One of the most widely used configurations is the original commercial model FM-1 unit marketed in the 1960s by Princeton Applied Research (PAR) Corporation. This unit utilized Foner's basic principles. My VSM uses these same basic principles with modifications related to the advancement of microelectronics, most important the use of a lock-in amplifier to obtain the signal.