# Magnetic Materials: Domain Observation

There are many methods of imaging magnetic domains either directly or indirectly. Indirect techniques such as the Bitter method involve decorating the domain walls and imaging the decoration media. Direct methods however image the domain structure by the direct interaction of light, electrons or, more recently, a magnetic probe with the magnetic fields of the sample.

**The Bitter method**

The Bitter method is a refinement of the well-known demonstration using iron fillings to map out the magnetic field in the vicinity of a bar magnet. In this technique a fine colloid suspension of $Fe_3O_4$ (magnetite), usually referred to as ferrofluid, is dropped on the surface of the specimen and a glass cover slide is placed over the top. Under the action of the gradient in the stray magnetic fields, the colloid particles are attracted to the regions of maximum magnetic field, which coincide with the lines at which the domain boundaries intersect the surface.

**Magneto-optic methods**

These methods make use of the effect of the domain magnetization on the polarization of plane polarized light observed by reflection from the surface of a specimen (Kerr effect), or by transmission through the specimen (Faraday effect). Both of these techniques have the advantage that changes in the domain pattern can be followed and that the sample can be subjected to a magnetic field, heat, strain etc during the observation. The small order of the optical rotation, however can lead to experimental difficulties.

**Kerr Effect**

When plane polarized light illuminates the surface of a magnetic specimen, the reflected light is in general elliptically polarized. Figure 8 shows a Kerr effect image from a sample of $Nd_{16}Fe_{76}B_8$ (atomic%). The image has been taken using a conventional metallographic microscope fitted with a polarizing filter, to plane polarize the incident beam, and an analyzing filter, in the reflected beam at ~90° to the polarizing filter, to generate magnetic domain contrast. The domain pattern shown is usually referred to as a "cog wheel" pattern and is observed when uniaxially anisotropic samples are sectioned perpendicular to their easy direction of magnetisation. When the sample is sectioned with the easy direction of magnetisation in the plane of the section then a striped pattern is observed, with the easy direction parallel to the stripes.

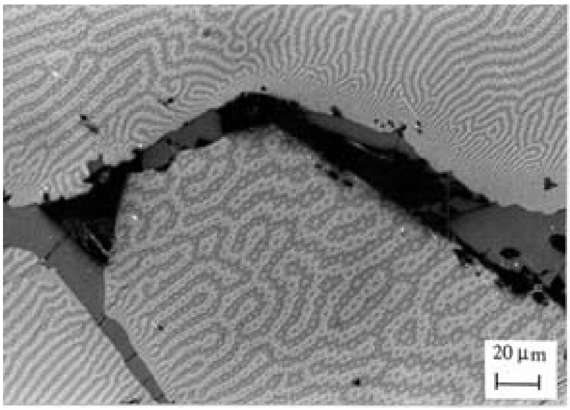


***Figure 8:*** *Kerr effect image from homogenised $Nd_{16}Fe_{76}B_8$.*

The Kerr effect has been developed as an accurate method of characterising the magnetic properties of thin film samples that could not be measured by conventional methods due to the small volume of magnetic material present. It has also been used as a method of recording digital data where ones and zeros are stored as magnetic domains magnetised in one direction or the other. The data is then read back using a laser spot scanned across the magnetic surface.

**Faraday Effect**

This is similar to the Kerr effect except that the rotation of the axis of polarization is caused during transmission of light through a ferromagnetic solid. Its use is therefore restricted to thin slices of ferromagnetic oxide or films and is thus less useful than the Kerr effect for domain observation.