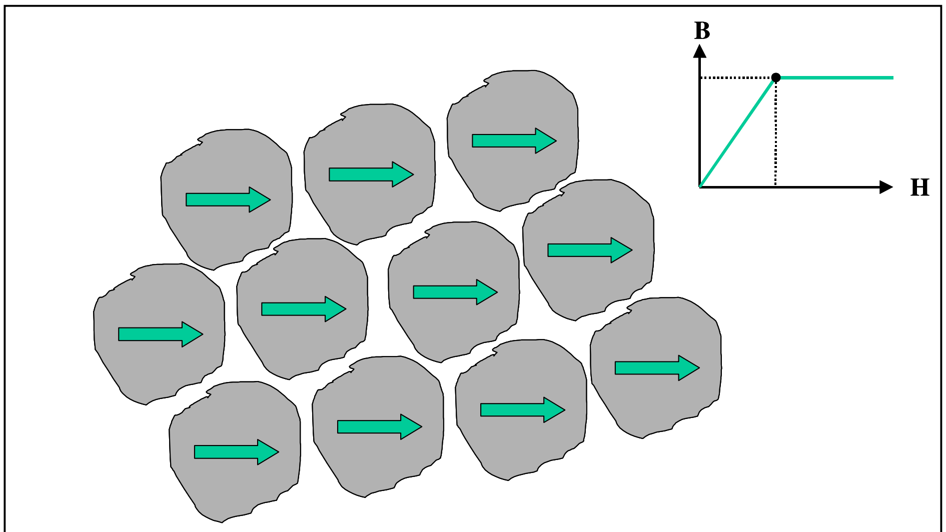
Even More Thoughts on Graham's Transformer

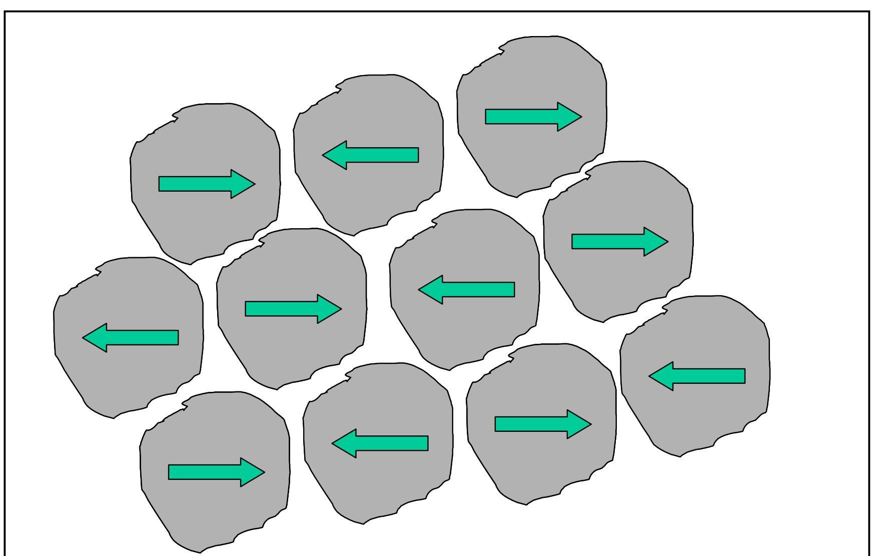
©Cyril Smith, July 2016-07-21

High permeability ferrites are highly anisotropic, they have a greater permeability in the wanted direction along the core than across the core. They are manufactured by grinding down standard ferrite into fine grain sizes that are then individual single domains. Each grain acts like a single dipole with its axis fixed within the grain. This powder is then put with a binder into a mold ready to be fired back into ceramic form. However during the firing process a strong magnetic field is applied to align the grains/domains so the net result is all the dipoles get a fixed alignment in the final ceramic, and this is the high-perm axis. You then get the situation where variable permeability along the magnetic axis comes about from domain flips. The figure below shows the grains with all their domains flipped into the spin-up state, the material is fully magnetized.



Fully magnetized (to saturation), all domains spin-up

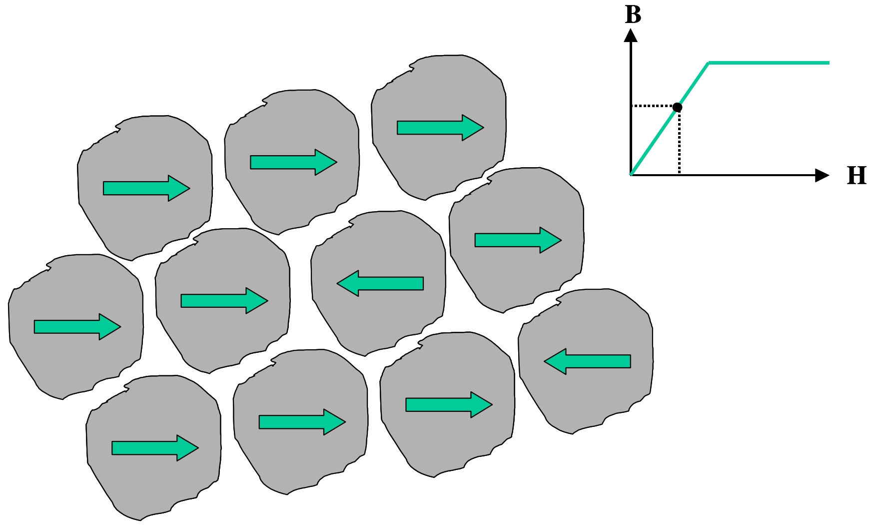
The next figure shows zero magnetization, the grains are 50% spin-up and 50% spin-down.



Unmagnetized, domains 50% spin-up and 50% spin down

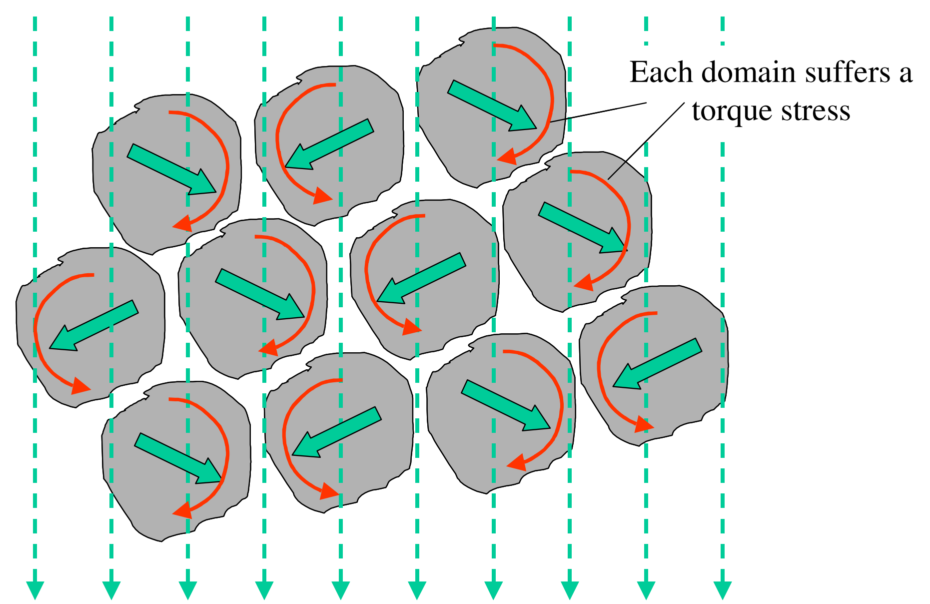
With an applied field along the high perm axis (horizontal in the figures), as the field increases more and more grains flip to the spin-up condition yielding the classical BH curve, where the rapid slope tends towards a large Barkhausen jump as many grains flip almost at the same time.

The next figure shows only partial magnetization, the grains are either spin-up or spin-down and here there are more spin-up than spin-down.



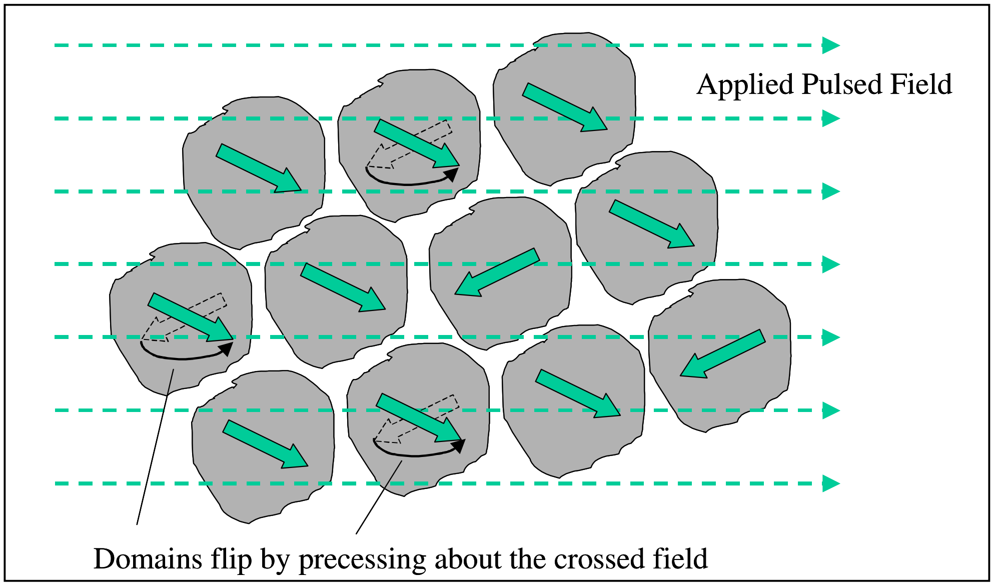
Partially magnetized, more domains spin-up than spin down

What happens when there is a strong crossed field? Each grain will undergo a torque force as each dipole tries to align itself with the crossed field. This is illustrated in the next figure.



Crossed Field

The application of a high magnitude cross-field results in only a small sideways magnetization, the material exhibits low permeability in that crossed direction. It may now be conjectured that the application of a pulsed field along the core axis that will cause some of the domains to flip, in doing so they could actually precess around the crossed field. This is illustrated in the next figure.



If this theory holds water the precession frequency could be peculiar to the anisotropic high-perm material, and may not occur in other materials. The relatively low frequency of Graham's device suggests that the frequency could be associated with the stress and strain characteristics of the material, the torsional stress on each grain changes direction when the dipole flips.