For which field direction do you expect the higher lying M(H) curve?

A. H_1

B. H_2

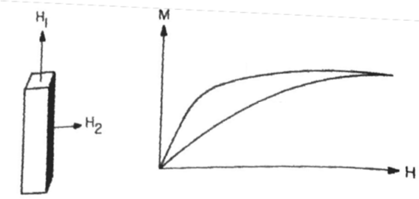
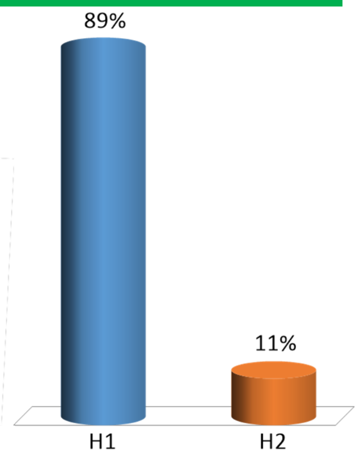


Figure 2.1 Magnetization curves for a polycrystalline ferromagnetic sample with field applied in different directions.



The field orientation indicated by H1 results in the higher lying magnetization curve assuming that the shape anisotropy provides the dominant anisotropy energy. The demagnetization tensor component acting along the long axis is smaller than the ones for the transversal directions. Magnetization M along the H1 direction results hence in a smaller magnetostatic energy, compared to H2 direction(s).
H1 can be considered as being an easy axis. Consistently, the area between the hysteresis curve and the y-axis (M-axis) should be smaller when H is applied collinear to the easy axis compared to the other orientations.

For which of the scenarios do you expect the largest energy product?

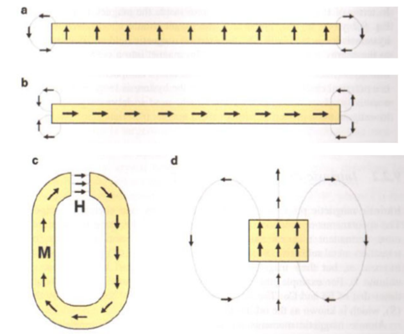
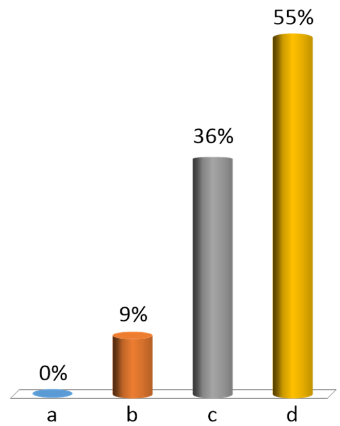


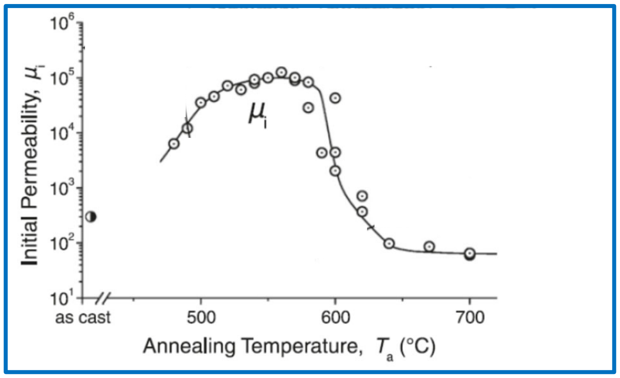
Fig. 9.3 Permanent magnetism and magnet shape: (**a**) thin film with perpendicular magnetization, (**b**) thin film with in-plane magnetization, (**c**) horseshoe-like flux closure geometry, and (**d**)

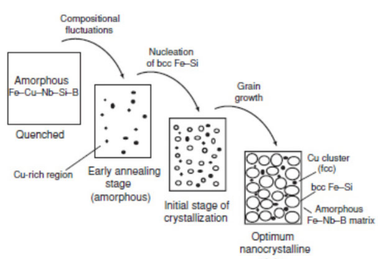
A. a
B. b
C. c
D. d

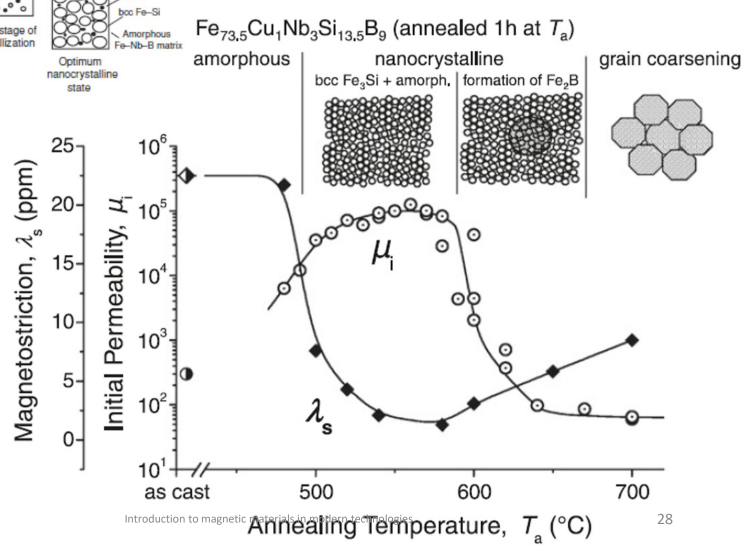


The energy product (BH) reflects the energy density provided by a (hard, permanent) magnet. The figure-of-merit maximum BH-product, i.e., (BH)max was defined in the 2nd quadrant of the B(H_int) curve. As field lines B must close in space a large (BH) in the 2nd quadrant means also a large (but sometimes distributed) magnetic field density B in the space surrounding the magnet. In scenarios a and b there are only few field lines leaving the magnet, hence the energy density in the surrounding space is small. In c the density of field lines in locally high in the gap but the volume to harvest this field density in an application is very small. Scenario d is the "good compromise" for a magnet's shape which gives rise to a large energy product to be exploited outside the magnet.

The graph shows the permeability of a compound consisting of $Fe_{73.5}Si_{13.5}B_9Nb_3Cu_1$. The material is amorphous in the as-cast state. Find arguments why the permeability varies as a function of annealing temperature.
Can you explain the increase and decrease of μ?







The complete answer can be motivated by the additional graph shown on page 4. The as-casted material is on the one hand still heterogenous and on the other has a large magnetostrictive coefficient. The first aspect means that domain walls might get trapped in defects such that a large(r) field is needed to magnetize the material coming from zero field. Close to zero field the initial permeability u_i = M/H is defined. The second aspect gives rise to (local) magnetic anisotropies in the material whenever there is a stress field or strain. Arbitrarily orineted anisotropies reduce a magnetic premeability as well assuming that H is not applied along the specific/local easy axis.
With moderate annealing the amorphous material becomes more homogeneous and the magnetostrictive coefficient reduces as well.
The impact of both aspect diminishes and the soft-magnetic properties improve.
Annealing at too high temperatures lead to a growing diameter of crystallites such that magnetocrystalline anisotropies reduce the softness, particularly as energy barries scale with K_u x volume of a nanocrystal.