Micromagnetic Simulation of Domain Wall Pinning in $Sm(Co,Fe,Cu,Zr)_z$ Magnets

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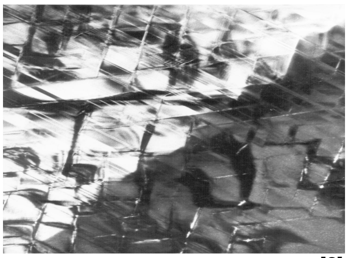
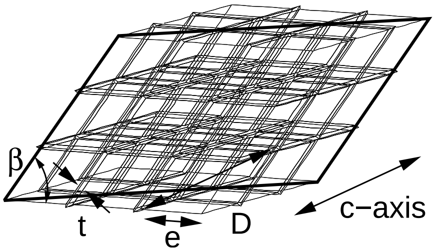
Introduction

Samarium-Cobalt type permanent magnets were discovered in the 1960's by Strnat and coworkers [1]. The high magnetic moment of Sm and Co as well as the high magnetocrystalline anisotropy are the reason for the excellent magnetic properties of this material. Furthermore the high Curie temperature of 720 ° C for $SmCo_5$ and 820 ° C for Sm_2Co_{17} [2] makes it the best material currently available for high temperature magnets.

Micromagnetic Model



[3]



[5]

z-values

t (nm)	$V_{2:17}$ (nm^3)	$V_{1:5}$ (nm^3)	ratio	z
2.5	28738	2358	12.187	8.13
5	28738	4843	5.934	7.81
10	28738	10202	2.817	7.31
20	28738	22570	1.273	6.64
40	28738	54643	0.526	5.93

Results

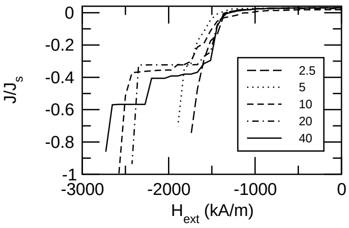


Fig. 1: Demagnetization curves for varying thickness *t* (values in the legend in nm) of the intercellular phase.

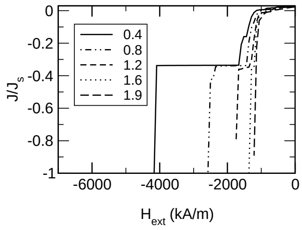


Fig. 2: Demagnetization curves for varying anisotropy constant K_1 of the cell boundary phase (values in the legend in MJ/m^3) - attractive pinning.

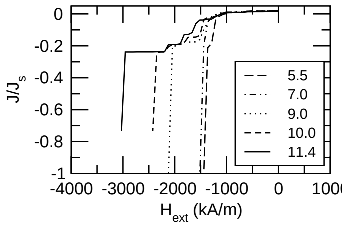


Fig. 3: Demagnetization curves for varying anisotropy constant K_1 of the cell boundary phase (values in the legend in MJ/m^3) - repulsive pinning.

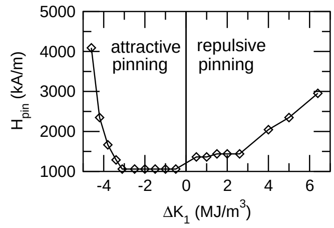


Fig. 4: Pinning field vs. difference in anisotropy constant between the cells and the cell boundary phase.

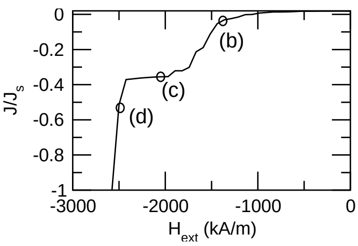


Fig. 5: Demagnetization curves for *D*=250 nm and *t*=10 nm.

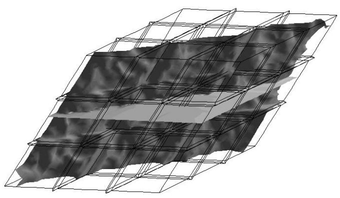


Fig. 6:
H_{ext} = -1360 kA/m
J/J_s = -0.03

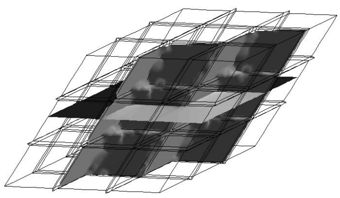


Fig. 7:
H_{ext} = -2040 kA/m
J/J_s = -0.35

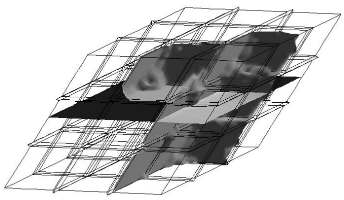


Fig. 8:
H_{ext} = -2500 kA/m
J/J_s = -0.53

Conclusions

In order to improve the magnetic properties of pinning controlled $Sm(Co,Fe,Cu,Zr)_z$ magnets the thickness and the composition of the cell boundary phase have to be optimized. Our simulations show, that the thickness of the cell boundary phase plays a crucial role for attractive domain wall pinning, since it must not be too thin, for the domain wall to "fit in" and it must not be thicker than 4 times the domain wall width.

References

[1] K. J. Strnat and G. Hoffer and J. Oson and W. Ostertag, J. Appl. Phys. 38 (1967) 1001-1002
[2] K. D. Durst and H. Kronmüller and W. Ervens, Phys. Stat. Sol. 108 (1988) 403-416
[3] T. Matthias, J. Fidler, G. Zehetner, T. Schrefl, D. Schobinger, G. Martinek, J. Magn. Magn. Mater. Submitted - JEMS '01 paper no. J-034.
[4] J. D. Livingston, D. L. Martin, J. Appl. Phys. 48 (1977) 1350-1354.
[5] E. Estevez-Rams, TEM study of the correlation between microstructure and magnetic properties of novel hard and soft magnetic materials, Dissertation, TU Vienna (1996).
[6] M. J. Donahue, R. D. McMichael, Physica B 233 (1997) 272--278.