RELAXOR-BASED THIN FILMS MEMORIES AND THE DEPOLARIZING FIELD PROBLEM.

Manuel I. Marqués and Carmen Aragó

Dpto. de Física de Materiales, C-IV, Universidad Autónoma de Madrid, Spain

ABSTRACT

Thin film memories based on ferroelectric materials are a topic of main interest in the computer industry. Nanomemories consisting on a few layers of ferroelectric materials such as $BaTiO_3$ could be a promising solution to the problem of miniaturization. However, when a ferroelectric memory is written by inducing a polarization different from zero in the thin film, a depolarizing field spontaneously appears, due to the existence of uncompensated charges at the substrate. If the width of the memory is very small (down into the range of nanometres) the depolarizing field increases to a value large enough to cancel the polarization [1].

In a simple first neighbour model we have found a mathematical relation between the lateral size of the memory (L), the width (D), the screening of the charges at the substrate (S) and the strength of the ferroelectric interaction (J) by considering the different energetic contributions to the system. We find that in order to obtain a polarization different from zero (not cancelled by the depolarizing field) the width of the ferroelectric memory must be $D > SL/2J$. So, miniaturization to a single layer is usually forbidden for a given set of (L, S, J) values.

On the other hand, new kinds of materials named relaxors elicited more and more attention from the ferroelectricity researchers during last years. Relaxors are materials with an intrinsic disorder [2**]**. This intrinsic structural disorder seems to result in the existence of nanodomains that persist even at high temperatures. Using the Random Field Ising Model, we consider that each nanodomain is affected by a different random electric field. The behaviour of these random fields when polarizing the relaxor has been studied lately in some detail [3].

In this paper we propose a possible mechanism to cancel the effect of the depolarizing film in thin film memories based on the use of relaxor nanolayers. Under the hypothesis of an internal organization of the random fields inside the nanolayer we show analytically how it should be possible to miniaturize the memory to a width as small as D=1 for any value of L, J and S. Further numerical and experimental work is in progress in order to test the viability of this theoretical proposal.

REFERENCES

[1] J. Junquera, P. Ghosez : Nature 422, 506 (2003)
[2] L.E. Cross, Ferroelectrics : 76, 241-267 (1987)
[3] M.I. Marqués, C. Aragó : Europhysics Letters 71 (1)**,** 124-130 (2005)