Growth Anisotropy of Fractal Domain Structures

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1. Introduction

Domain structures developed in stochastical growth process has been recently shown can reveal the property of self-similarity [1,2]. This observation allows try to use fractal dimensions for qualitative and quantitative description of domains grown, for example, by pit degradation in magneto-optical data storage devices. Because the real magneto-optical discs are characterized by local anisotropy due, for instance, tracks, scratches, etc. it is of important to investigate effects of anisotropy on the speeding of domain walls.

Stochastical domain morphology is determined by competition of randomizing and ordering forces. Among the latter the stiffness of domain wall and anisotropy should be noted. If the character of influence the stiffness of domain wall on fractality is rather obvious - the energy of domain wall and demagnetization energy determine the smallest scale of domain pattern then the role of anisotropy is not so transparent.

In order to clear up this question we consider the growth anisotropy of domains. Such anisotropy in amorphous films can be caused, for instance, by mechanical processing (tracks, scratches, applications).

2. Model

Using the model of thermoactivated domain growth developed in [2], it is easy to imagine the growth anisotropy as nonequality of DW displacement probabilities in different directions. In particular, for two-dimensional square lattice the relation left-right (LR) and up-down (UD) displacement probabilities can be introduced by

\[ p = \frac{p_{\text{UD}}}{p_{\text{LR}}} = \exp \left( - \frac{E_a}{T} \right), \]

where \( E_a \) is an anisotropy energy, \( T \) is the temperature.
Fig.1 The anisotropic growth process on two-dimensional square lattice. The pictures are obtained after 100, 300 and 1000 Monte Carlo steps. Anisotropy parameter $p=0.8$.

3. Discussion

Typical domain patterns arising from anisotropic stochastic growth process are shown in fig.1. The growing domains can be characterized by tip-to-tip dimensions along axis $X$ and $Y$, respectively. It seems that $\langle X \rangle$ (here $\langle .. \rangle$ means the configuration average) diminishes as domain structure grows. Hence, during the time the structures grow into rodlike objects. This process at different $p$ is depicted in fig.2.

On the other hand, simulations show that $\langle XY \rangle$ changes linearly with respect to domain square $S$. It means that the structure is compact (global fractal dimension coincides with Euclidian one). Therefore, the growth anisotropy destroys the self-similarity of domain structures, now the geometry of patterns could be characterized by set of scaling dimensions in different directions. These dimensions are not universal and depend on the size of cluster. Such evolution of stochastic domain structures resembles anisotropic diffusion-limited aggregation [3]. Probably, the growth process in both cases is governed by global geometry of cluster (diamond).

4. References

