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FEATURES OF MAGNETIC STRUCTURE ANALYSIS IN SOFTWARE "ZUBR"

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In this paper describe software package ZUBR. This software was developed for analysis of magnetic structures. The structure of this software is described. This structure provide for task magnetic image preprocessing, measurements investigation and analysis of tree type of magnetic structure.

Introduction

In order to gain insight into the properties of magnetic materials and performance of devices it is important to be able to study the magnetic domain structure of the material or device under investigation. Magnetic domains are regions of unidirectional magnetization which are governed by one of the fundamental laws of nature – minimization of energy in the system. The knowledge of domain structures is of great importance of the fundamental physics of magnetism, as well as technical application.

In the last years we have been a growing interest in ultrathin magnetic films properties relating the magnetic domain structure and magnetization reversal process [1,2]. The magnetic microstructure is strongly correlated with the film morphology in the atomic scale, which in turn is determined by the growth conditions. Interesting magnetization distributions can be expected after some magnetic material modifications e.g. by patterning, special buffer, and overlayer structure.

A number of different techniques to study the domain structure of magnetic materials exist today. One such technique is the magneto-optical imaging technique which has significant advantages of being relatively inexpensive, non-invasive and applicable to a broad range of magnetic samples. The observation of the domain structure was performed using the longitudinal magnetoopical Kerr effect in a wide-field optical polarizing microscope equipped with CCD camera and image processing technique. The video signal was electronically processed, subsequently digitized and then improved by standard image processing techniques (including subtracting of reference image). Spatial distribution of the remnant state in the sample was studied on the basis of I(i,j) matrix images. A computer controlled set-up enabled changes of: (i) sample image I(i,j) registration time, (ii) pulse amplitude $H_\perp$ and its duration Δ (Δ=1 s was in experiments described below) of the magnetic field perpendicular to the sample plane.

The following procedure was used for domain structure study during magnetization reversal: (i) the reference image $I_-(i,j)$ was registered after sample saturation in $H_\perp<0$ ("black" direction), then (ii) remnant domain structure image $I_{DS}(i,j)$ was recorded in zero magnetic field after application of a pulse of the $H_\perp>0$ ("white" field direction, Δ duration time). Each resulting images was calculated using the formula: $P_{DS}(i,j)=I_{DS}(i,j)-I_-(i,j)$.

There are many software packages of image processing that are used for analysis magnetic structures [3-5]. But these software packages include function of image preprocessing for improving magnetic image and common image processing procedure. We are developing new software package that include function of analysis of separate magnetic structures and calculation complex characteristics for description of its evolution.

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1. Magnetic structures

There are many different types of magnetic structures [6]. We observe four basic configurations of magnetic structures in ultrathin magnetic films in the frame of two types of magnetization reversal.

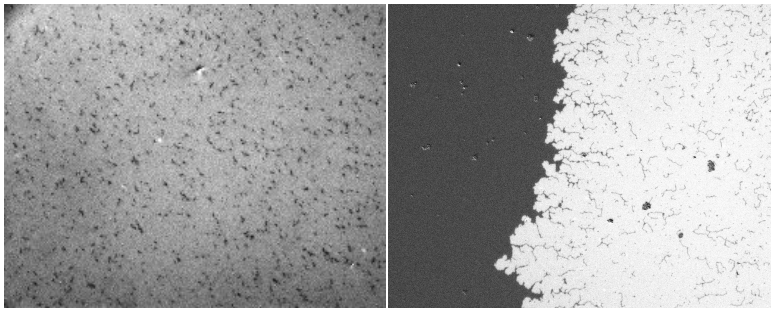
(A) Magnetization reversal proces is characterized by many nucleation centers in observation area.

1. Blobs (fig. 1a): they are solid objects, without internal structure; blobs growing is isotropic.

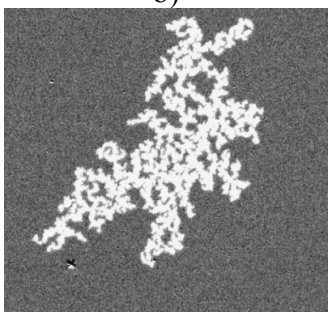
(B) Magnetization reversal proces is characterized by limited number of nucleation centers in observation area.

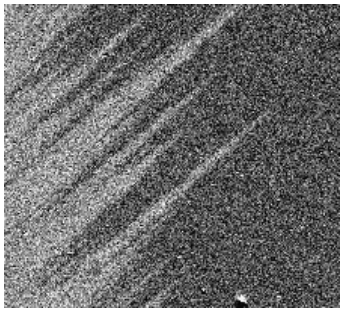
2. Front (fig. 1b): this is a big object that is characterized by flat growing in one direction.
3. Needles (fig. 1c): they are very elongated in one direction objects. Usually they have sharp terminations.
4. Dendrites (fig 1d): they are very complex objects. Dendrites represent connected structure of branch.

Other objects usually constructed by these four types of structures.



a) b)





c) d)

Fig 1. Four types of magnetic structures: a) blobs, b) fronts, c) needles, d) dendrites.

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This magnetic structures classification lay on base additional features of software package "Zubr".

2. Organization of software package

The software package "Zubr" is developing by toolsets LabView. This software package allow to processing 10 images. Every image describe by index, palette, zoom and are presented in separate special window (fig. 2).

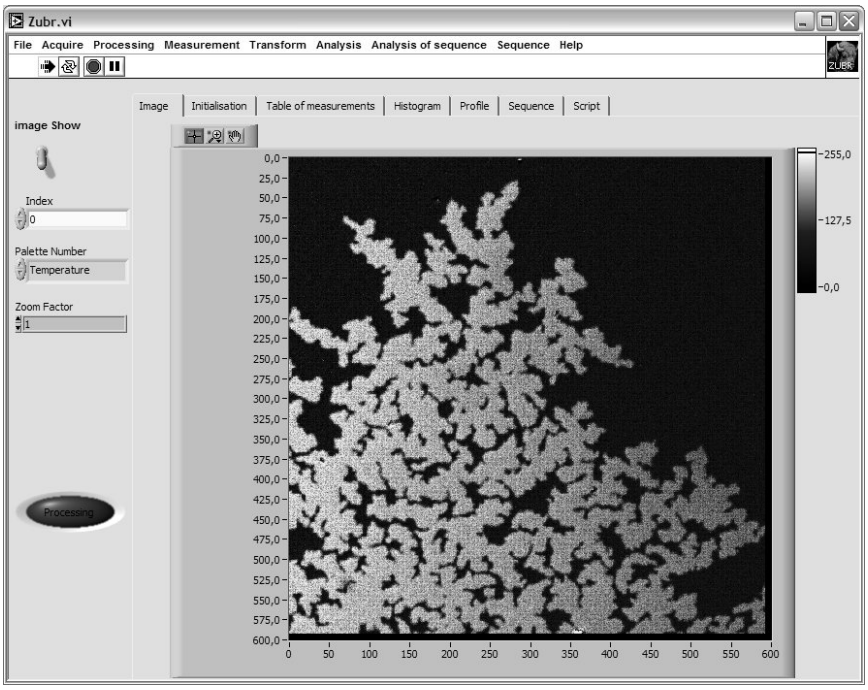

Fig. 2 Shell of software package Zubr.

Workspace of software package is divided into menu and working panel. Menu allows selecting operation for image processing or analysis. Working panel can include graphics and tables with results of analysis and fields of image description.

Functions of this software are divided into tree functional group (fig. 3):

- common image processing,
- static analysis of magnetic structure,
- dynamical analysis of sequence of magnetic images.

The group of common image processing includes function of input or output organization, image improving, background correction, segmentation, transformation and traditional interactive tools for image editing and measurement.

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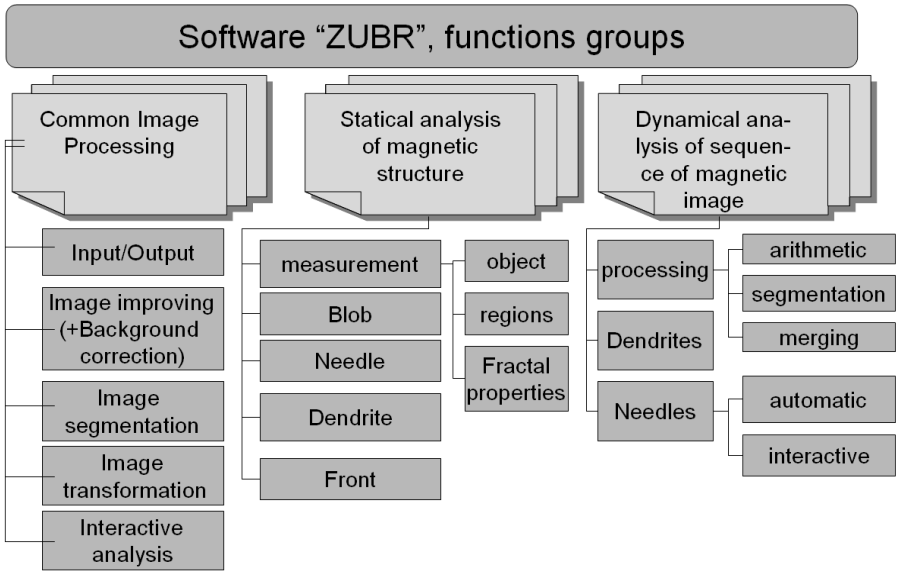

Fig. 3. Common structure of software package Zubr

The group of static analysis of magnetic structure include as traditional function: measurement connected objects and few regions and fractal properties, as additional functions of analysis of blobs, front, needles, dendrites. Additional functions include phases of object extraction and calculation of specialized characteristics and features.

The group of dynamical analysis of magnetic images also includes traditional tools of processing sequences of images and additional tools of structures changing. Additional tools are evolution of static function of analysis. But tools of dynamical analysis are organized as separate virtual instruments. They can be started from basic package and from program shell LabView. The every function of dynamical analysis has unique dialog for process management (fig. 4).

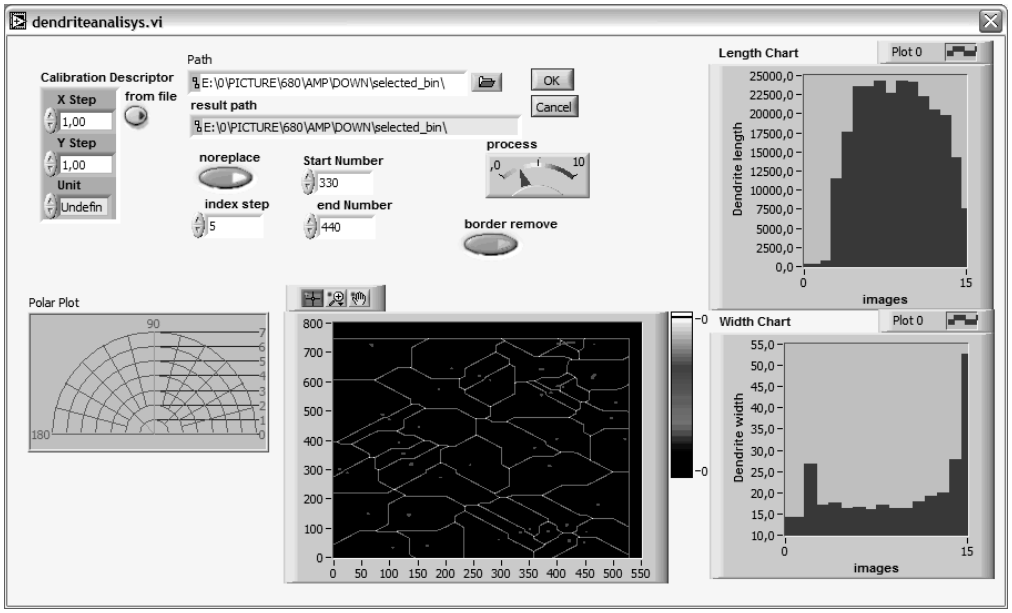

Fig. 4. The special dialog of dynamical analysis of dendrites structure evolution.

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The sequences of the images is usually investigate for the analysis of the evolution of the domain structure during the magnetization reversal process. In this connection, the image processing managing in Zubr has complex structure (fig. 5).

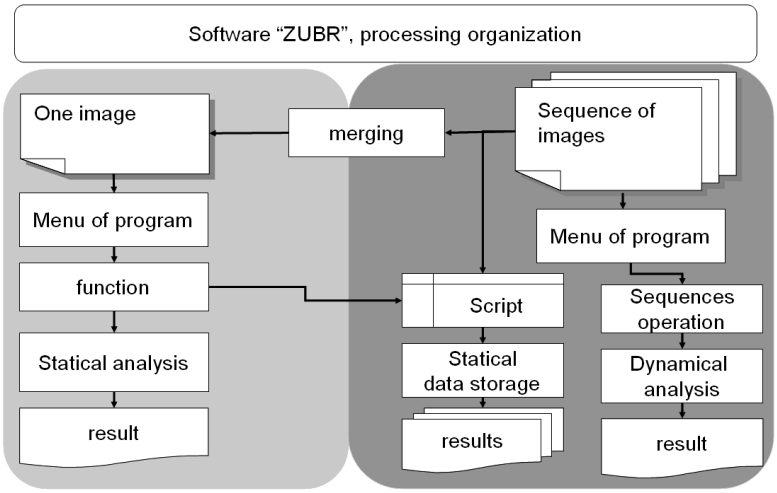

Fig. 5. The structure of images sequence processing in Zubr.

This structure includes two parts for one image processing and sequence processing. For one image processing usually image is extracted from sequence or is creating by images merging. In phase of one image processing, the user can develop script by using image processing functions through menu. The user can repeat processing by script for every image from sequences. In this case calculated characteristics for objects like as array of results of one image processing.

Conclusion

The software package "Zubr" has unique function for magnetic structures image investigation. The analysis divided to four basic groups: blobs, fronts, needles, dendrites. This groups are basis for analysis many other more complex structures. The software package "Zubr" allows to study static structures and it evolution. The fact of developing this package in LabView allows to use this along with instruments of managing of physical experiments. It is necessary to use LabView for investigation of dependence of magnetic structures and different physical characteristics.

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