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IMAGES PROCESSING AND ANALYSE FOR IDENTIFICATION AND DETERMINATION OF STRUCTURE DEFECTS

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Abstract
The current developments in communications, microelectronics and medicine ask for the use of better quality single crystals. This is why crystal characterization through different methods is very important. In this paper are presented some aspects regarding the characterization of materials by the Crystal Growth Laboratory of The West University of Timisoara. A special focus is on the identification of structural defects and determining their spatial density using tools for processing and interpreting images obtained using optical microscopy.
Keywords: Defects, bubbles, dislocation, image processing

1. Introduction

The aluminum oxide (Al_2O_3), in its pure chemical form is the base substance for the production of sapphire single crystals. The sapphire is a crystal with remarkable properties. It's high mechanical hardness and optical transparency to a large spectrum of wavelengths makes the sapphire an excellent material for optical devices and it is widely used by the military in optical components for the guidance and targeting subsystems. Sapphire shaped single crystals (obtained using EFG method – [1, 2]) always present structural defects. These defects depend generally on the growth conditions. The macroscopic inclusions with dimensions larger then 10^{-8}m, are typical defects for sapphire shaped crystals. These so-called voids or microbubbles absorbed and dispersing the light altering the crystals quality. The gas bubbles have a negative effect on the crystals qualities. Their dimension can reach several micrometers. In some cases the bubbles have a regular distribution and can be found at the crystal's edges or in the core of the crystals. In other cases their distribution appears not to respect any rule. The gas bubbles in shaped sapphire crystals can be observed trough optical microscopy on the lateral surface of the crystal without any processing (Fig. 1a) or on the transversal section after an initial polishing process (Fig. 1b).

Classical methods of crystal characterization imply a visual investigation. To increase the speed of the characterization process, the identification, classification and quantification of the defects can be done using software tools. The tools are included in an application that uses images acquired using a CCD camera adapted to an optical microscope. The application has a collection that can be used in image processing and interpretation. The first stage in the application's evolution is the development of a tool that can identify and quantify the gas bubbles in shaped sapphire crystals.

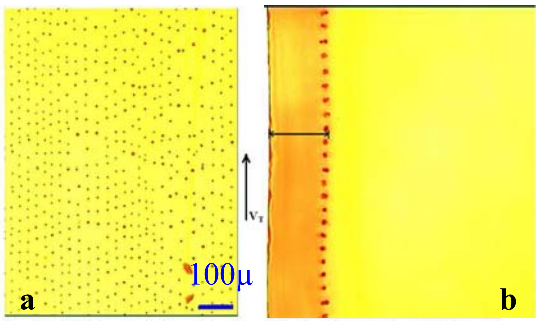


Fig. 1. Gas bubbles: a) lateral surface. b) – transversal section.

2. Model description. Results and discussions.

2. 1. Tools for image processing.

Classical tools.

The simplest methods of image processing are very useful in the enhancement of the original image. Contrast, color and noise filters can isolate the defects to simplify the interpretation or future processing (Fig. 2).

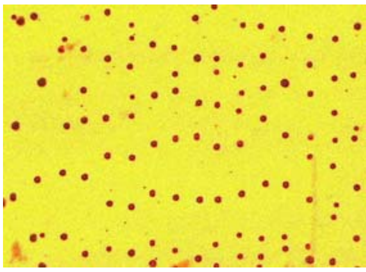
Fig. 2. Defect enhancing using simple filters.

Special tools

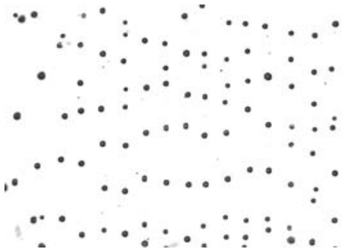
To obtain a semnificative increase in contrast but without loss of quality we can use the histogram stretch tool. This tool produces a much more clear separation between the pixels. The CCD cameras are sensitive in the infrared spectrum. This makes them vulnerable to termic noise. This inconvenient can be eliminated by acquiring an image with the camera optured. The resulted image can be extracted from the original image to obtain a much clear image without the background noise. The pixel profile tool returns a graph of different values of the pixels (lightness, color, hue, etc.). The result can also be a database that can be used by other tools or applications. This tool can be very useful in the process of developing new tools.

2. 2. Tools for image interpretation

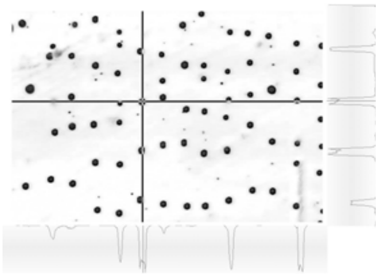
The tools for image interpretation are adapted to identify, classify and quantify the crystal's defects automatically (Fig. 3).



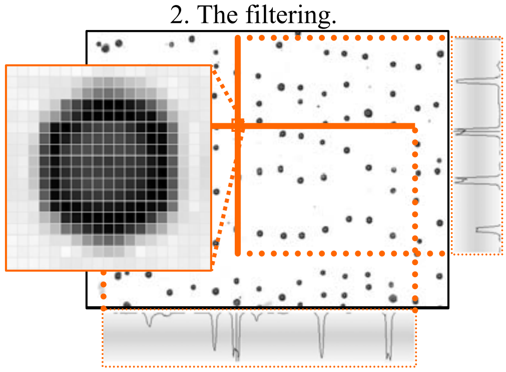
1. The image is aquired and loaded in the applicaton.



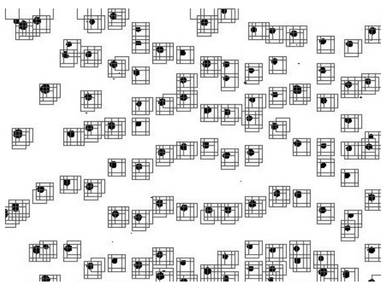
2. The filtering.



3. The search for the regions of interests



4. The extraction of the region of interest and defect validation



5. The final result.

Fig. 3. Tools for image analyse.

In the case of the sapphire crystal obtained by EFG method we want to quantificate and determine the density of the gas bubbles created during the crystal growth process. The application steps trough several stages to obtain the desired result (the position of all the defects in the crystal) are:

1) An image of the crystal is acquired using the CCD camera adapted to an optical microscope.
2) The image is filtered to eliminate the background noise. The tolerance level for the noise can be set manually or can be chosen automatically by the application.
3) The application is detecting the regions of interest. A region of interest is an area of the image where a defect can be found. The regions are detected by comparing the Ox and Oy pixel profile, a local symmetry indicates a region of interest and a possible defect.
4) The region of interest is extracted and feed to a neural net that will validate or invalidate the region as a defect. The neural net is a basic feed forward neural net that has a matrix as an input (the image of the region of interest).
5) Once all the defects are identified the application will output a map with all the defects. The result can also be a database with all the positions and sizes of the defects, database that can be used for future processing.

3. Conclusions

This application can be very useful in the crystal characterization process. Precious hours can be saved by letting the software to do the time consuming task of defect detection and quantification. The future development of the application will include tools adapted to other types of defects (dislocations in calcium fluorite or brome clorurite).

References

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