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A Strategy For Macrodefects Coordinates Detection In Oxide Monocrystals.

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ABSTRACT

The article considers a new technique that allows to automate the process of quality control and marking of single crystals, to increase the accuracy of localization of macrodefects. Also, the working model of the measuring unit, which is searched for defects in a number of crystals of aluminum garnet, is considered.
Keywords: macrodefects, oxide monocrystals, aluminium.

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INTRODUCTION

The precise information about the macrodefects locations allows to adjust the technological process and cut the products from the pure zones during the oxide monocrystals manufacturing process. The proposed strategy enables to: acquire the information about precise locations of such macrodefects as another phase inclusions, gas blisters within crystals volume; perform a mathematical data processing; obtain statistical information about the defects' density dispersion. It is of crucial importance to get the reliable information about the light-dispersing macroscopic inclusions during oxide crystals manufacturing such as saphire and yttrium aluminum garnet. [1] The issue here that the manufactures mostly rely on and restricted by the primary visual evaluation, which in its turn does not eliminate a high inaccuracy rate within the acquired data [2], since this measure is a quality-based one. The crystal information preserving is carried in a sketch form in one or more planes [3]. A more precise method is to shoot a series of photos [4, 5], the camera position is however made manually, moreover there is no precise information on the planes location, which were in focus. The issue resolution seems to lie in the robotization domain, which would enable to get precise shots with the measurements data and inclusions coordinates. The main idea of this strategy is a photo shots series automated acquisition, for which the focus is set in different crystal layers with a predetermined increment.

METHODS AND MATERIALS

A crystal is set onto the measuring instrument, which is a table (see Figure 1). The vertical positioning of the table is made with an incremental driver. It is also possible to implement with a static table and a moving camera (see Figure 1). At the starting point, the camera is focused on the crystal's base, then the crystal is moved down, until its upper part is in focus. The photo shoots and incremental driver control is synchronised and performed by the preinstalled software. Thus the defects, depicted on the shots correspond to the real coordinated in the crystal. The shots are analyzed via an OpenCV library [6], which enables to define the defects areas boundaries.

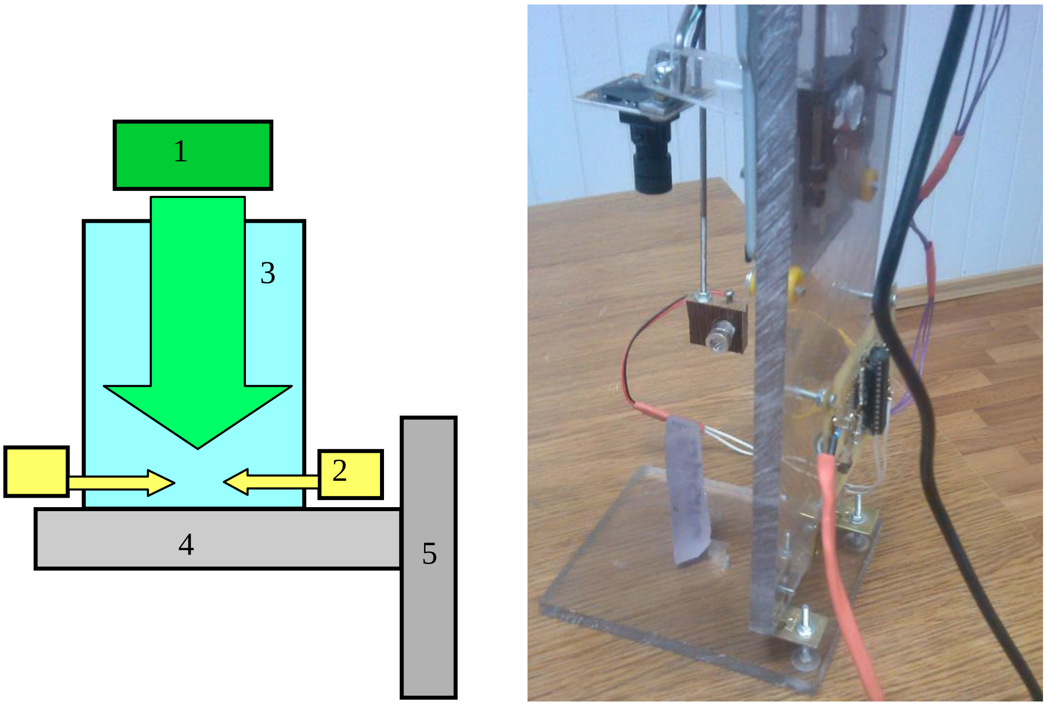

Figure 1: The scheme and the facility appearance; 1 – camera; 2 – the lights; 3 – crystal; 5 – table; 6 – incremental driver

This strategy was developed to define defects, which are more than 40 Microns. The camera optical system focal length can be calculated in the following equation:

$$f=(C*L)/D,$$

for which C is matrix's CCD width, L is the crystal's length, D is the crystal's diameter.

The optimal matrix resolution is calculated by the following equation:

$$N=(n*D/d)^2,$$

for which N is the total quantity of pixels in the matrix, n is a quantity of pixels for a single defect, D is the crystal's diameter, d is the defect's size.

For the programmed defects identification, a range of methods was used, the most widespread are as follows:

1) The Hough transform for lines, circles and other simple shapes search on the picture. The searched item is represented in a form of a parametric equation. For every picture's point the equation's calculation is carried out. The found points correspond to the maximal values of the searched function.

2) Object pattern detection. To implement this method two series of shots are prepared with and without defect correspondingly. Then a neural network learning is taking place, which enables further detection of such objects on shots.

3) Object color search. If the searched volume is different from background color, this method provides good results, being the most easy one to implement.

According to the defects positions on the shots, a 3D model is built and the statistical parameters are calculated.

RESULTS AND DISCUSSION

The strategy was tested on a set of yttrium aluminum garnet crystals, containing the macroinclusions zones agglomeration. The lights were made with a LED-embedded construction and a semiconductor laser flat light beam. Series of shots, were processed via a custom-made software (see Picture 2), the acquired data enabled to build a defects dispersion chart (see Figure 3), it demonstrates the possibility of this strategy application for a monocrystal manufacturing technical process setup quantitative evaluation

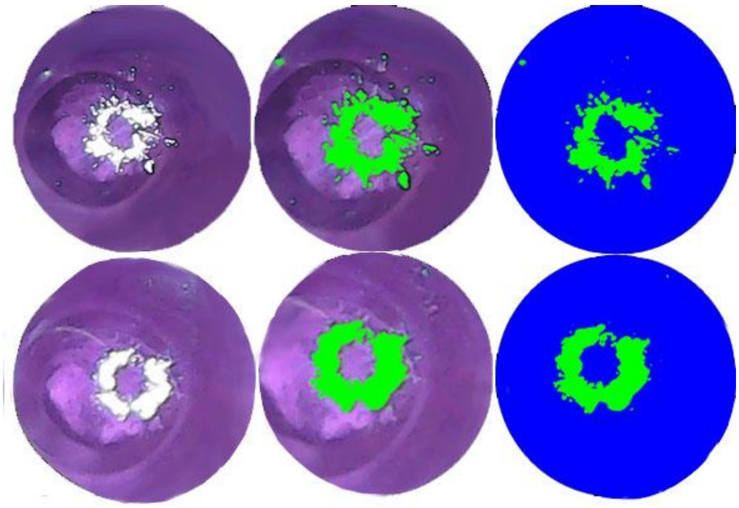

Figure 2: Shots of the two cuts during different production stages

Figure 3: Inclusions dispersion through the crystal's length

CONCLUSION

A strategy was developed as a result of the research. The strategy enables to automate the quality control process and the monocrystals marking-off; increases the precision of the blisters detection, the second phase inclusions and other macrodefects. A working prototype of a measuring instrument, was built and tested for defects detection for a set of yttrium aluminum garnet crystals.

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