Optical-electronic technologies in materials analysis

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Veacheslav L. Perju, David P. Casasent, Valeriy S. Feshchenko, Lubov V. Feshchenko, "Optical-electronic technologies in materials analysis," Proc. SPIE 5816, Optical Pattern Recognition XVI, (28 March 2005); doi: 10.1117/12.604321

SPIE.

Event: Defense and Security, 2005, Orlando, Florida, United States

Optical-electronic technologies in materials analysis

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ABSTRACT

It is proposed a new optical electronic approach for effective, simple and non expensive testing of the materials. An optical correlator is used for high speed features extraction, which characterize the distribution of the informational important elements in the crystallographic image. The digital "portrait" of the analyzed material is constructed which is compared with the set of the standard "portraits" on the base of which the level of the quality of the material is determined. The method permits to automate the process of the crystallographic images analyses and to increase the reliability of the results.

Keywords: analysis, correlator, image, feature, material, optical-electronic, system

1. INTRODUCTION

In the different countries from former Soviet Union, Europe etc a big part of market consists of falsified products such as medicines, spirits drinks etc. which are produced by no licensed companies. This influences negatively on the health of the population and on the State's budget. The financial circulation of the "black" market constitutes a sufficient part (up to 70%) of the State's budget, which represents the real treat for National security.

In these conditions the elaboration of the effective, simple and non expensive testing methods and systems for operative analyses of the materials is of a great importance.

Optical Pattern Recognition XVI, edited by David P. Casasent, Tien-Hsin Chao,
Proceedings of SPIE Vol. 5816 (SPIE, Bellingham, WA, 2005)
0277-786X/05/$15 doi: 10.1117/12.604321

One of the perspective direction in the materials analysis is based on the examination of their crystallographic images[1]. The advantages of this approach are high sensitivity and comprehension, repetition and cheapness.

The known crystallographic methods[1-3] of materials testing are based on the analysis of the images by experts which do not permit in many cases to realize real time process. There were different attempts to automize the analysis of the crystallographic images[4]. But these approaches permitted only to determine the informative fields in the image for using in the experts decisions acceptance. Also, the disadvantage of these approaches consists in the low reliability of the results due to subjectivity in perception by different researchers of analyzed crystallographic images, which are characterized by high complexity. The experts' opinion in many cases depends on their qualification and experience.

We propose a new approach, which permits completely to automate the process of the crystallographic images analysis, to increase the reliability of the right decisions and the productivity of the materials' testing.

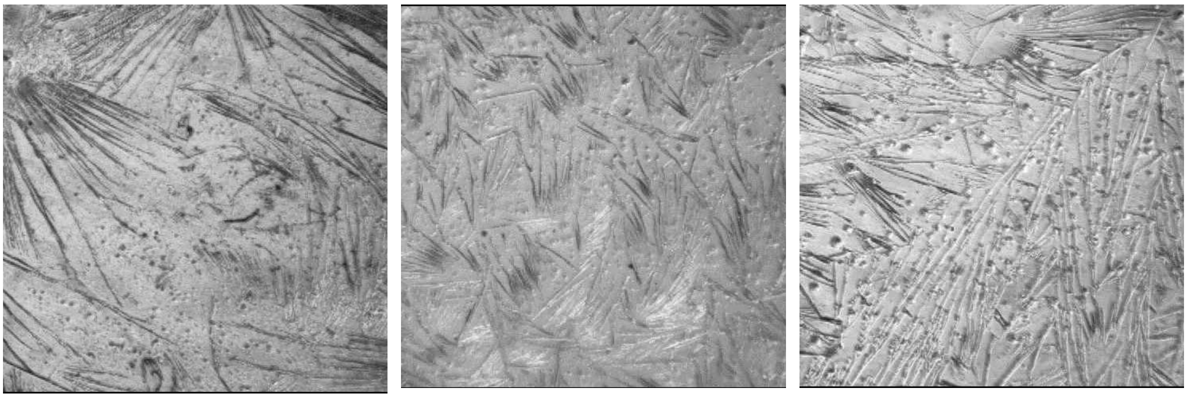
We suggest to use a special purpose optical electronic system for crystallographic images analysis. This system contains an optical processor for rapid extraction of the features from the crystallographic images, introduction of these features in the computer and their processing by special algorithms. An optical correlator is used as optical processor in the system, which permits to form the features with high speed (approximately 10^{15} bits/sec). This will decrease sufficiently the time of crystallographic images' analysis.

2. FORMATION OF THE CRYSTALLOGRAPHIC IMAGES

The crystallographic images can be produced by different methods[4]. One of them is based on the evaporation of a dissolvent from a bio liquid placed on a glass. The bio liquid represents the water solution of mineral substance with organic components such as sugar, proteins etc. For example, in medical diagnostics for obtaining the crystallographic images are used the blood, urine, salivary and lachrymal liquids, intestinal, stomach and pancreatic juices, cellular lymph etc.

Another method is based on introducing a fixed amount of a bio liquid into a solution of known material (usually cuprous chloride). At the process of evaporation are forming the crystallographic structures. The degree of changing of the obtained structure from a known structure may serve as the diagnostic feature.

As an example, the crystallographic images of some Moldavian cognacs are presented at fig.1. These images were produced as follows.



a b c

Fig.1. The crystallographic images of: a – cognac “Belii Aist”, b – cognac “KVINT”, c – brandy “Solnechniy”

We mixed hydroquinone (2% water solution) and investigated cognac in a proportion 5:1. Further this solution was placed on a glass. Than we evaporate a liquid at standard atmosphere pressure and temperature. After that the crystallographic patterns were captured and introduced in the computer.

3. THE METHOD OF MATERIALS ANALYSIS

In accordance with our approach, the initial crystallographic image is introduced into the optical correlator, where with high speed the image features are extracted. These features characterize the distribution of the informational important elements (IIE) in the image. As IIE we used “dot”, “star” and “line” (fig.2). The element “dot” describes the dots inclusion. The element “star” describes the crystallization centers. The increasing of number of these elements characterizes the increasing of the pathology probability. Elements “line” contains the information about the length, thin, direction of rays of the crystal grains. The distinctiveness of pathology is the density of the crystals on a unit area. If this density is increased and the uniformity of the body height is less expressed, the probability of a pathology is increasing.

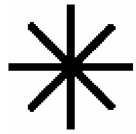
		
a	b	c

Fig.2. Informational important elements: a – “dot”, b – “star”, c – “line”

The structure of the optical correlator is presented on fig.3. The He-Ne laser 1 beam is reflected from the mirrors 2 and is collimated by an optical system consisting of lenses 3, 5 and pinhole 4. The collimated beam is modulated by a crystallographic image from the spatial liquid-crystal modulator (SLM) 6 connected with computer 12. The SLM 6 is placed on a front focal plane of the lens 7. Another SLM (8) is placed on a back focal plane of the lens 7. On this modulator the correlation filters of the informational important elements are presented.

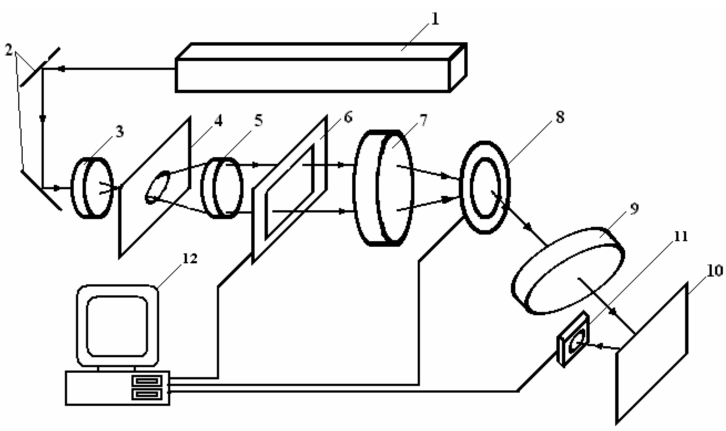


Fig.3. The optical correlator

In the correlation plane 10 are formed the correlation maxima, the number of which will characterize the number of the respective IIE in the analyzed crystallographic image and represent the features of this image. The correlation plane 10 is scanned by camera 11 and the respective image with IIE is introduced into the computer 12, where it is forming the digital “portrait” of the analyzed material. The “portrait” is compared with the set of the reference “portraits” of the materials, which are characterized by deviation from the standard materials, such as presence of another substances, changing of the structures, etc. which characterize the falsification of the products, diseases etc. On the base of the comparison’s results is established the level of the quality of the initial material.

In table 1 are presented the data which characterize the features of the different cognacs. It is possible to observe that the number of correlation maxima characterizes the quality of the drink. The digital "portraits" of the investigated drinks are presented on fig.4.

Table 1.
The features of the cognacs

Nr.	The kind of drink	Number of "dots"	Number of "stars"	Number of "lines"
1.	Cognac "Beliy Aist" (4-5 years age)	28	26	15
2.	Cognac "KVINT" (2-3 years age)	23	23	12
3.	Brandy "Solnechniy"	16	16	11

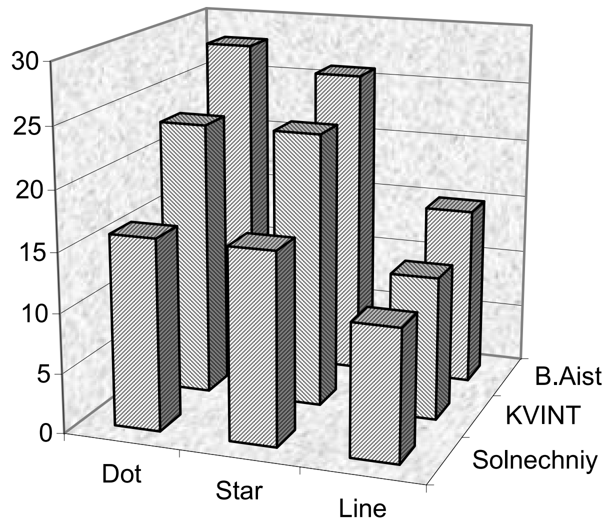


Fig.4. The digital "portraits"

4. ANALYSIS OF THE EXPERIMENTAL RESULTS

From the experimental results we can conclude, that the analyzed drinks have a different number of correlation maxima to each of the informational important elements. The number of responses for "dot" and "star" is higher than for "line", and approximately is equal among themselves. The total number of correlation maxima grows at increasing of the age of the drink. This is connected with decrease of the size of the image structure, and bigger number of the branches in crystallites.

It is possible to observe also, that the digital "portraits" of a cognac "Beliy Aist" and brandy "Solnechniy" fundamentally differs. The producing technologies of these drinks are different, although both they are made on the bases of the five years age cognac alcohol.

5. CONCLUSION

We propose a new approach of materials testing, based on statistical analysis of the crystallographic images using the correlation method. The main advantages of this approach are:

1. Improved technology of materials testing and possibility to automize the crystallographic image analysis process.

2. Increased reliability of the right decisions in materials analysis due to absence of the subjectivity of the crystallographic images perception by experts.

3. High speed of the material analysis due to utilization of the optical correlator.

Proposed approach can be successfully used in different fields. In wine, food and pharmacology industries – for testing the quality of the products in the manufacturing process and to discover the falsified products in the trading networks; in medicine - for diagnostics of the diseases; in criminalistics - for identification of the substance's composition; in ecology - for detection of the toxic substances in alive organisms etc.

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