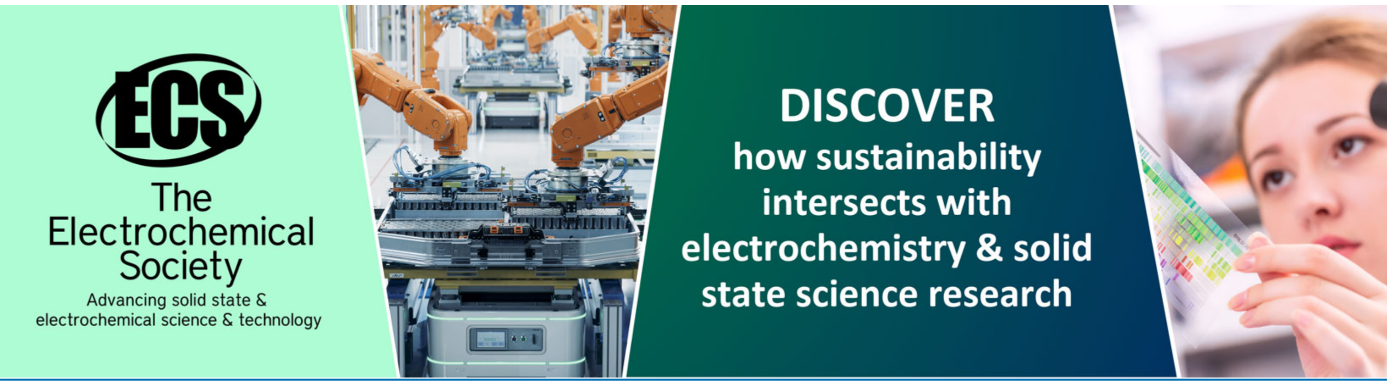
IOP Conference Series: Materials Science and Engineering

Non-replicable object surface development for its automatic identification

To cite this article: L S Beckel and V D Shkilev 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **450** 052013



IOP Conf. Series: Materials Science and Engineering **450** (2018) 052013 doi:10.1088/1757-899X/450/5/052013

Non-replicable object surface development for its automatic identification

L S Beckel and V D Shkilev

Kaluga branch Bauman Moscow State Technical University, 2 Bagenov street, Kaluga, 248000, the Russian Federation

E-mail: milla2606@rambler.ru

Abstract. Each object has a set of attributes that help determine its essence and distinguish it from many other similar ones. Solving the problem of automatic identification to prevent counterfeiting is currently an urgent task, since the existing technologies cannot guarantee reliable protection from falsification of production.

1. Introduction

The study of automatic identification methods revealed their shortcomings. It is almost impossible to determine an object from a number of similar ones belonging to the same category and it is not difficult to copy an object. Therefore, in order to carry out a reliable identification procedure, it is necessary to apply a fundamentally different approach, i.e. to use a unique characteristic applied to the object. For this purpose, the stochastic physical process must be based on the technology of applying such an irreproducible surface. The study aims at developing the technology of getting the unique object characteristic, which will guarantee its reliable authentication.

The analysis of the existing methods using stochastic physical processes to provide an object with unique characteristics proved to be rather undeveloped [1-5].

2. Electric discharge method for non-replicable object surfaces

The lack of reliable identification technology caused the authors' interest in the physical nature of the electric discharge process, which has been used to destroy rocks, large objects, water purification, pipelines, grinding of plant raw materials [6-9]. In this article, it is proposed to apply the electric discharge method for applying a non-replicable surface for object identification, allowing to recognize a unique characteristic and identify an object on the basis of the developed automated system.

In Kaluga Branch of Bauman Moscow State Technical University, a series of experiments was conducted to obtain non-reproducible surfaces on paper documents placed between two electrodes. The choice of this research object is related to the need to protect securities, identity cards, education and qualification documents, accompanying documents for products from their forgery.

To obtain a non-replicable document surface, an electric discharge unit was assembled, the parameters and operating modes of which were obtained during calculations [10]. From the technologies for obtaining different types of discharges, the avalanche-streamer discharge was selected as providing a large number of destruction channels stochastically disposed relative to one another. An important condition for its creation is the application to an interelectrode gap of a highly inhomogeneous electric field, the magnitude of the voltage of which must exceed the critical value [11-13]. The overvoltage factor was determined for the development of a discharge in the air gap, since the introduction of a solid dielectric into the interelectrode gap causes the discharge to proceed with a smaller electric field. The resulting non-replicable surface is a set of stochastically located holes (figure 1).

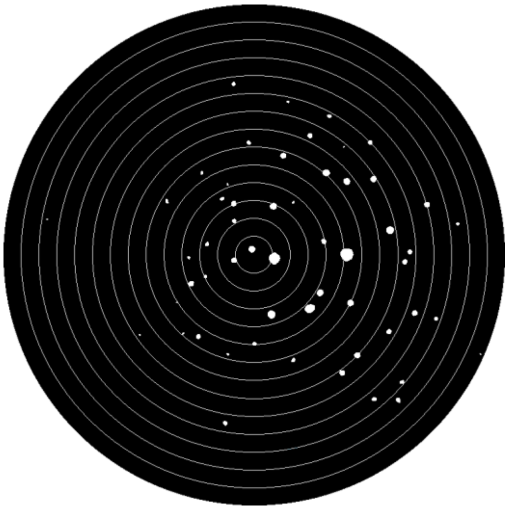


Figure 1. Non-replicable surface with concentric circles.

3. The interference characteristic of the failure channel location

The distribution estimate of the number of holes, their areas and centers over the target surface was made with the help of a developed automated system.

When considering the surface perforations (holes), it is not difficult to verify their stochastic distribution. In addition, with an uneven density of the paper carrier, the holes were also found in areas with a dense structure, whereas it was previously noted that during the passage of an inhomogeneous dielectric the fracture channel develops in places with the lowest density [14, 15]. During the experiments, the authors made the assumption that under the created conditions for creating a dielectric breakdown, when electrons pass between the cellulose molecules, an interference pattern of the location of the destruction channels will appear. This assumption was theoretically confirmed by cellulose structure taking into account the de Broglie hypothesis.

The interference pattern resulting from the addition of waves is characterized by the distance between the interference bands Δx between the neighboring maximum values of the amplitudes. This value can be determined by the formula [16]:

$$\Delta x = \frac{d\lambda}{a},$$

where d = interelectrode gap, a = distance between molecules of a crystalline dielectric.

The average distance between the molecules of cellulose is assumed to be equal to $2{,}8 \cdot 10^{-10}$ м [17]. Then the distance between the fringes becomes:

$$\Delta x = \frac{10^{-2} \cdot 5{,}234 \cdot 10^{-12}}{2{,}8 \cdot 10^{-10}} = 1{,}869 \cdot 10^{-3}[\text{м}] = 1{,}869[\text{мм}].$$

To confirm a theoretically grounded assumption about the presence of an interference phenomenon during the application of holes in the conditions of electric breakdown of a paper carrier, various sets of perforations were processed with the help of an automated information system. For this purpose, the character of the distribution of the area sums of burned holes that hit each of the annular subregions of the target was studied (concentric circles were applied to the target perforations of the target) and its center part (figure 1).

By the nature of the waves, we can conclude that there is an interference phenomenon on cellulose crystals: the maximum amplitude of the waves significantly (four times) exceeds the mean value (figure 2).

The width of the interference fringe, due to the oscillations of various factors affecting the electric discharge process, was within 1.8-2.05 mm, which agrees well with the theoretically suggested value (1.869 mm).

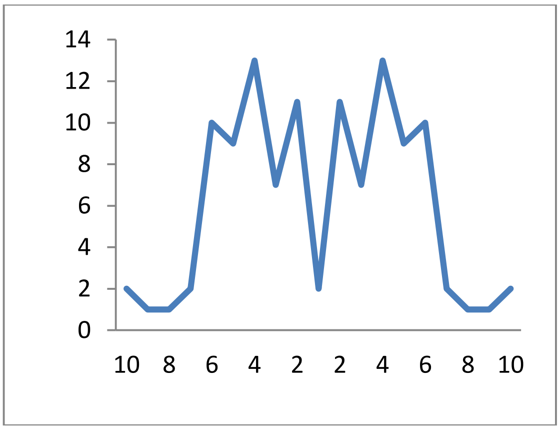


Figure 2. Hole areas distribution example.

4. Automated identification process

The document was identified as follows (figure 3) [18].

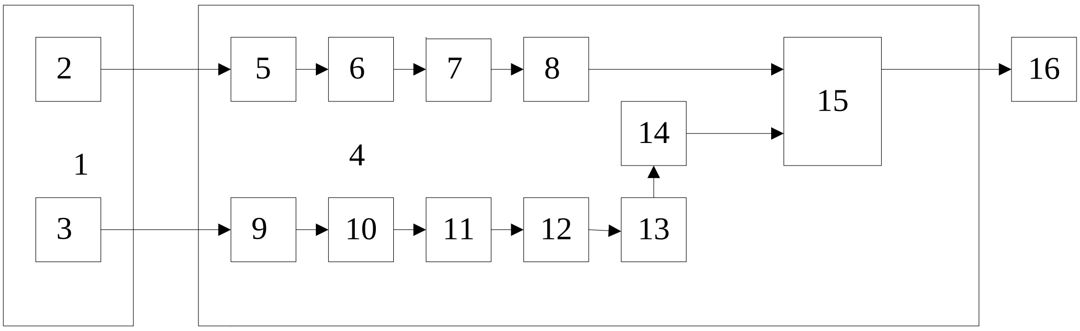


Figure 3. Automated system operation principle.

A two-dimensional code with alphanumeric encryptions was printed on the paper substrate (1) after processing and coding the identification features of the unique characteristic (2) (series and document number, number, coordinates and hole size) by an automated system its confirmation 3. Writing a large amount of information in the code makes it possible to avoid using databases designed to store the reference information contained in the received characteristics. The sequence of operations to verify the identity of the document was as follows. The scanning and processing device (4) scanned the non-replicable surface (2) and stored its image in the memory of the device (5) (a common smartphone camera). The binary image of the surface (2) stored in the memory of the device (5) was digitized (procedure 6). Then, identification tags were identified (procedure 7), and a digital code was created (procedure 8). Authenticity of the read surface (2) is verified during the execution of subsequent counter procedures: 9 - scanning of two-dimensional code 3; 10, 11 - storage of two-dimensional code (3) and its decoding; 12 - obtaining a signature containing information about a genuine digital code; 13 - verification of the digital code; 14 - receipt of a true digital code. 15 - bit-by-bit comparison of the digital code obtained as a result of reading and processing the surface (2) on the document, with a genuine digital code of two-dimensional code (3). If they coincide with a certain accuracy, then the document is recognized as genuine. Procedure 16 represents the decision on the document authenticity. It is implemented as a message generated by the device (4).

5. Results and conclusions

During the series of experiments, the results of paper documents identification have been obtained. Figure 4 shows examples of identifying genuine document results. Each non-replicable surface had a various number of deposited apertures. The dimensions of the holes and the coordinates of their mass centres also differed from each other. The horizontal axis shows the column numbers - the results of the identification procedure, the vertical axis shows the number of holes applied by the electric discharge method. Documents with various number of holes were chosen - from 70 (column 1) to 22 (column 7).

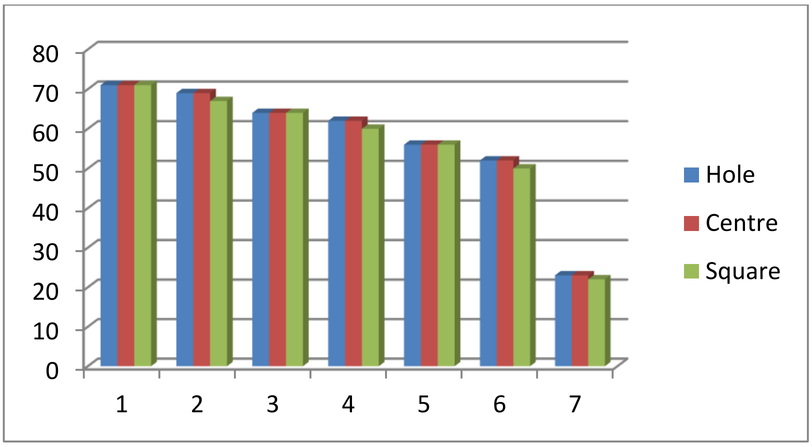


Figure 4. Diagram of original documents identification results.

Diagram 4 shows that the information system demonstrated good results when identifying originals from a variety of falsified documents. The magnitude of the compared values deviation from the total coincidence did not exceed the permissible threshold of 5%. Very different diagrams were obtained when comparing falsified documents with genuine ones (figure 5). The horizontal axis of the chart shows the column numbers, the vertical axis shows the results of the identification procedure, the number of holes for which the match occurred. The coincidence is possible by parts of two holes of the counterfeit document (the total number of holes was 70). But the areas of the parts of these holes differ from the reference values, and there was a coincidence in the coordinates of one hole mass centre.

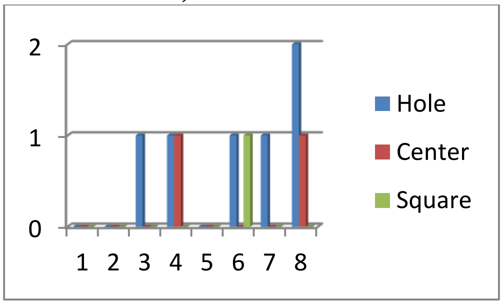


Figure 5. Diagram of comparing results of the original data with forgery.

Thus, the proposed new identification technology allows to confirm the authenticity of the document with high accuracy, i.e. to make reliable object identification.

References

[1] Lebedev A T 2003 *Mass spectrometry in organic chemistry* (M.: BINOM. Laboratory of knowledge) p 493

[2] Lyapidevsky V K 1996 *Method of marking and identification of objects* Patent RU 2064697
[3] Pappu R, Gershenfeld N and Smith JR 2003 *Identification and verification using complex, three dimensional structural features* U.S. Patent 6584214
[4] Kravolec E 2002 Plastic tag makes foolproof ID *Technology Research News* **2** p 75–85
[5] Anderson R 2001 Security Engineering: a guide to building dependable distributed systems *Wiley* pp 251-2
[6] Greenstein G and Zajonc A 2008 *The Quantum Challenge. Modern Research on the Foundations of Quantum Mechanics* (Dolgoprudny: Publishing house Intellect) p 473
[7] Gurevich A V and Zybin K P 2001 Runaway breakdown and electric discharges in thunderstorms *Physics-Uspekhi* **44** 1119-40
[8] Kurets V I, Soloviev M A, Zhuchkov A I and Barskaya A V 2012 *Electrodischarge technologies for processing and destroying materials* (Tomsk: Tomsk Polytechnic University Press) p 272
[9] Saushkin B P 2004 Electric discharge in liquid and gas environments is the basis of a new generation of methods and technologies of machine-building production *Electronic material processing* **1** 4-17
[10] Shkilev V D, Haychenko V E, Filippova I A, Beckel L S and Golovacheva Yu G 2017 *Method for alloying metals and alloys* 2639176 (Moscow: Rospatent)
[11] Mesyats G A 2004 *Impulse power and electronics* (Moscow: Science) p 704
[12] Mesyats G A 1974 *Generation of powerful nanosecond pulses* (Moscow: Sov. Radio) p 256
[13] Butenko V A, Vazhov V F, Kuznetsov Yu I, Kurenkov G E, Lavrinovich V A, Mytnikov A V, Pichugina M T and Startseva E V 2008 *Technique of high stresses* (Tomsk: Tomsk Polytechnic University Press) p 118
[14] Vorob'ev G A., Eanin S G and Nesmelov N C 2005 Electric breakdown of solid dielectrics *Physics of the solid state* **47(6)** 1048-52
[15] Ushakov V Ya 2004 Physics of breakdown of liquid dielectrics *Engineering science* **307(2)** 80-7
[16] Zverev V A 2010 *Methodology and tools in modern optical engineering* (St. Petersburg: publishing house SPBU ITMO) p 364
[17] Aleshina L A, Gurtov V A and Melekh N V 2014 *Structure and physico-chemical properties of cellulose and nanocomposites on their basis* (Petrozavodsk: Publishing house of PetrSU) p 240
[18] Shkilev V D, Beckel L S and Shkilev D V 2018 *Monetary note, the method of its manufacture and a way of confirming its truth and individuality* 2647375 (Moscow: Rospatent)