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Authenticity analysis of personal identity documents by the methods of holographic interferometry

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1. Introduction

New information technologies with increasing rate are entering into our daily life, internet commerce and different payments are spreading rapidly, more and more contracts are being signed by electronic signatures. Nevertheless paper or other material-based documents (cash banknotes, identity documents, acts of civil certificates, etc.) still are and will be a very important and inevitable in our lives. Under such regulative function of the documents, they are often counterfeited with selfish motivation. The problem of falsification and counterfeiting of the travel documents (mainly passports the Republic of Lithuania and other countries) becomes of crucial importance at the border crossing checkpoints where procedures of the document authenticity verification is performed or in case the indicators of any possible falsification methods are suspected the rapid decision on the right of the document holder to cross the border should be made. The term "travel documents" usually means common passports of the citizens. The other documents which can be included into this group are passports of foreign counties citizens, seaman's books, national personal identity cards and other.

Inspection procedures of travel documents of the citizens from the third countries usually take only a few minutes [1], therefore the role of both the human factor and technical means and methods applied to detect partial changes in a document or totally counterfeited document in the phase of primary inspection becomes very important. The view of border checkpoint workplace is presented in fig.1. Attention should be paid to the fact that according statistics of the State Border Guard Service more than 29 million citizens crossed the borders of the Republic of Lithuania through border checkpoints in 2010-2012 year [2].

Fig. 1 Work place at a border check point

In the REGULATION (EC) No 444/2009 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 28 May 2009 amending Council Regulation (EC) No 2252/2004 on standards for security features and biometrics in passports and travel documents issued by Member States is stated that Additional technical specifications in accordance with international standards, including in particular the recommendations of the International Civil Aviation Organisation (ICAO), for passports and travel documents shall be established - additional security features and requirements, including enhanced anti-forgery, counterfeiting and falsification standards [3] At Pan European High Security Printing Conferences which took place in the years 2010 and 2011 [4, 5] the issues of document falsification and counterfeit prevention and inspection were discussed and the latest technological means for document protection were presented. Relevance of the issue was also emphasised by Seimas of the Republic of Lithuania as the Criminal and Administrative Offences Code amendments in which the responsibility for counterfeit, possession, falsification of personal identity documents (passports, personal identity cards, birth certificates, certificates of employment, state social security certificates, driving licenses and others) as well as for usage of such falsification is defined. For illegal production, forgery or counterfeit of passports, driving licenses and other identity documents, or usage and possession of such false identity documents from now stiffer penalties - arrest or imprisonment from four to six years are being faced. Preparation of such amendments was stimulated by the growing number of the cases of forgery of passports and other identity documents in Lithuania as well as the fact that counterfeit and realisation of such documents takes a business like character.

At present 188 countries of the world (ICAO members) have the signed treaty on issuing Machine Readable Travel Documents – MRP – passport which complies ICAO recommendations, the requirements of ISO/IEC 7810:1995 and , ISO/IEC 7810:1995 standards [6]. MRP data page, which is the main object of falsification shall have the following basic sizes: 88.0 ± 0.75 mm × 125.0 ± 0.75 mm. MRP data page thickness including any final preparation (e.g. laminate), shall be as follows. No minimum thickness is specified. However, states are advised that currently available materials are unlikely to provide an adequately robust data page if the thickness is below 0.15 mm. Maximum thickness is

0.90 mm. Typical MRP data page (hereinafter – page) produced in the majority of EU countries has the recommended structure consisting of several polycarbonate foil layers and a layer of synthetic material, e.g. teslin. Page of the passports produced in Republic of Lithuania has analogous structure which is presented in Fig. 2. One of the European manufacturers of polycarbonate foil used for the pages is German company Bayer Material Science AG [7].

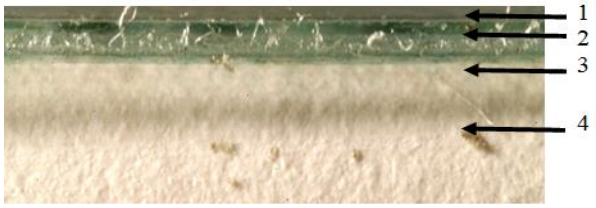


Fig. 2 Cross section image of the MRP data page of a travel document used by some EU countries. *1* – Protective polycarbonate transparent layer, thickness of which varies in the range of 50 – 100 μm; *2* – polycarbonate transparent layer for data recording of the thickness 100 – 150 μm; *3* – polycarbonate white layer of the thickness 200 – 550 μm; *4* – Protective teslin layer of the thickness 400 – 450 μm. [Document Analysis Department at the State Border Guard Service]

It can be distinguished the two main methods of the document forgery: making (by any method) a totally new document or by changing some part of an original document – adding (printing) falsified data, changing the original content by mechanical (erasing, scraping and similar) or chemical (washing, etching, painting by corrective material and other) means thus substituting the primary original data by other data. Rapid developments in the areas of science, engineering and technologies enhances the possibilities not only for experts but for counterfeiters as well, therefore classical areas of document expertise very often merge with the new areas or even transfer them the objects of analysis. The documents forged applying modern computer technologies rarely causes suspicions to the users as even stamps or signatures printed by high resolution colour of laser printers look like original if observing by naked eye and having no without expert skills.

Investigation results of the identity document (passport) forgery and counterfeit carried out by the institutions of The Ministry of the Interior of the Republic of Lithuania show that most frequently the pages are damaged by mechanical means in the zone of photo and data recording area. After damaging the page structure and putting efforts to restore its initial state, always residual technological defects remain (joining of polycarbonate foil layers and teslin layer by fusion or applying gluing materials and other). In Fig. 3 section view of a page which was mechanically damaged and then efforts to restore its primary state were made is presented.

When performing inspection of the possible page forgery at primary border checkpoints or the later analysis in the specialised laboratories various methods of non-destructive testing which differ by principles, hardware and software applied are used. The methods of visual inspection, laser, ultrasonic, acoustic emission, vibration methods, mechanical loading, thermo graphic, thermal emission and other methods can be applied. In publication [8] the method applied for authenticity verification a passport page which is in fact a multilayer polycarbonate teslin structure is based on the analysis heat transfer analysis. Particular values of physical parameters (in the case under analysis of thermal conductivity) in mechanically damaged and non-damaged zones were investigated experimentally.

Fig. 3 Cross-section view of a passport‘s page fragment after forgery attempts using a mechanical method. *1* – Protective polycarbonate transparent layer; *2* – polycarbonate transparent layer for data recording after the change of primary content; *3*, *4* – polycarbonate white layer after repeated gluing; *5* – Protective teslin layer after repeated gluing and/or fusion [Document Analysis Department at the State Border Guard Service]

The results of thermal transfer process modelling in the page structure when one side of it is heated uniformly by a constant temperature heat source are presented in the research. The obtained results prove that temperature difference on the opposite side surface of the page at damaged and non-damaged zones is sufficient to be detected by modern means and duration of the process and diapason of heating temperatures are suitable for practical application of the proposed methods for the inspection of travel documents. Nevertheless the proposed method is practically applicable for the page analysis only in statistically determined zones as inspection of the whole is relatively long in time.

Thermal load is also applied when performing holographic non-destructive testing of products. The first investigations in this area were carried out even in 1974. By means of holographic interferometry mechanical deformations of the whole surface of an object caused by changes in its surface temperature can be analysed. The analysed object can be heated by the flow of high temperature air, infrared or halogen lamps or other heat sources.

Taking into account technological peculiarities of the passport’s data page manufacture (fusion of the layers data recording, introducing protective elements and other), a hypothesis is assumed that after mechanical damaging of the page and then restoring its primary state residual mechanically damaged zones appear (air micro gaps, lack or excess of gluing material, fusion of the layers and other).

After applying a heat load on a page its physical and mechanical properties (such as thermal expansion including in the direction of page thickness) should change what would allow authenticity assessment of the page under inspection. In order to verify the hypothesis theoretical and experimental research applying one of the methods of non-destructive testing – the method of two exposition holographic interferometry having the resolution up to tenth parts of light wave length and the real time method which enables to observe thermal expansion process of the page in real time were carried out.

2. Experimental setup

The carried out experiment is based on thermal expansion of the page in the direction normal to its surface. Analysis of the expansion is performed simultaneously throughout the whole surface of the analysed structure when one side of the sheet is uniformly heated by a heat source of certain (selected) temperature and the results are fixed by the method of two exposition holographic interferometry. The principle of two exposition method is that in one hologram two different states of the page are fixed. For the first time the page being in its initial – stationary state is fixed, for the second time the page is fixed in its deformed due to thermal load state. In both cases the support wave (beam) illuminating the hologram remains unchanged. When recovering such hologram both fixed images of the page interfere one with another making a holographic interferogram (hereinafter – interferogram). Interference fringes can be observed on the page image recovered by the hologram. Localization, density and shape of the fringe lines on the page surface is the main qualitative indicator allowing to reveal even the smallest changes in surface deformations, which appear in between two expositions. The method can be implemented using constant radiation or pulse laser [9].

In order to analyse the influence of technological defects and forgery (local damages of polycarbonate film and teslin layer, application of inappropriate materials for joining the layers and other) on thermal expansion of the page in normal to its surface direction, holographic research stand PRISM (the faculty of Mechanical Engineering and Mechatronics of KTU) [10] and special holding frame of the page were used. The page is fixed in this frame along its all sides with the selected clamping force. Optical – structural scheme of holographic system PRISM presented in Fig. 4 allows implementing the method of holographic interferometry which is applied for non-destructive testing of the objects.

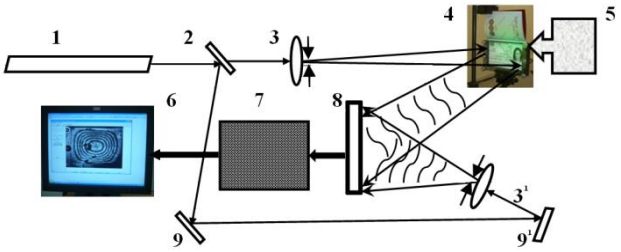


Fig. 4 Principal optical – structural scheme of holographic system PRISM. *1* – green colour (λ = 532 nm) 20 mW power semiconductor laser; *2* – mirror for splitting the laser beam; *3*, 3^1 – lenses systems for object and support beam expansion, *4* – analysed object - data page of a passport; *5* – adjustable heat source with diaphragm shutter and time meter; *6* - computer screen with an image of the monitored of deformed page; *7* - computer with installed special programme PRISMA-DAQ; *8* - special video camera registering interference image; *9*, 9^1 – full reflection mirrors

According this scheme beam of the laser *1* is split by mirror *2* to object beam, which with the help of lenses system *3* is spread and illuminates surface of the analysed page *4*, and light reflected from it reaches video camera *8*. Support beam which is formed by mirrors *9*, 9^1 and lenses system 3^1 also enters video camera *8* where interferes with light reflected from the surface of investigated page. The obtained interference image is processed by special programme in computer *7*. The obtained result is the image of interference fringes on the surface of investigated page and can be monitored on computer screen *6*. Adjustable heat source ensures the desired thermal load on the analysed page.

During experimentation by the method of two exposition holographic interferometry data pages of three passports were investigated: A passport – Lithuanian with reference (specimen) data page and other two - A and B with evident indicators of data page forgery.

In order to determine the reference deformation character of the data page expressed by interferograms (the reference for comparison of the future obtained results) data pages of Lithuanian and Norwegian passports were analysed the first by heating their surfaces and varying fixing conditions in the specially designed positioning frame (Fig. 5). As the applied holography methods enable to obtain deformation character simultaneously on all the surface of the investigated side of the page, the external heat inflow was uniformly distributed over all surface of the opposite side of the page. Uniformity of the distribution was controlled by electronic thermometers with 0.1°C accuracy. As a heat source the device with halogen lamp (300 W), the radiated heat flow and temperature of which were adjusted with the help of diaphragm and heating duration by a shutter was used.

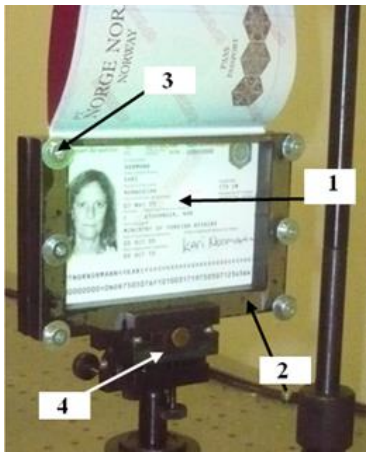


Fig. 5 Special holding frame for data page of a passport: *1* – analysed data page of a passport; *2* –basic part ensuring uniform fixing conditions along sides of the page; *3* –nuts for adjusting clamping force on the page; *4* –the unit for the frame‘s location adjustment along three coordinates in holography system

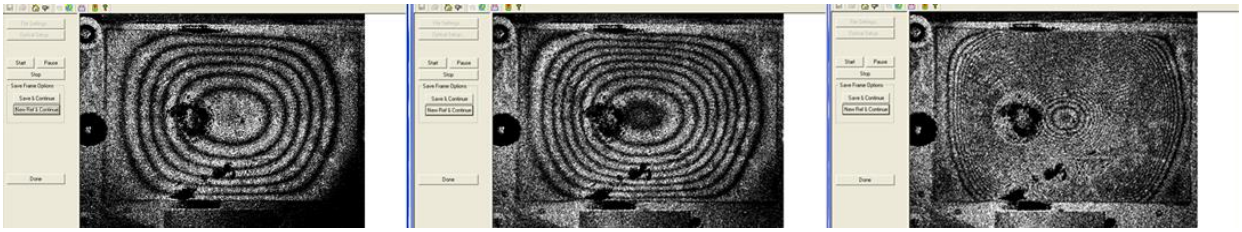
3. Results

During experimentation optimal distance between the heat source and the data page, temperature of the heat flow, optimal heating duration parameters of the data page fixing along its perimeter and the necessary clamping force were determined. Taking into account the fact that all sides of the page are to be fixed evenly with the same clamping force along the entire perimeter, it was determined that it is

sufficient to monitor thermal deformation of the page surface only in normal to it direction.

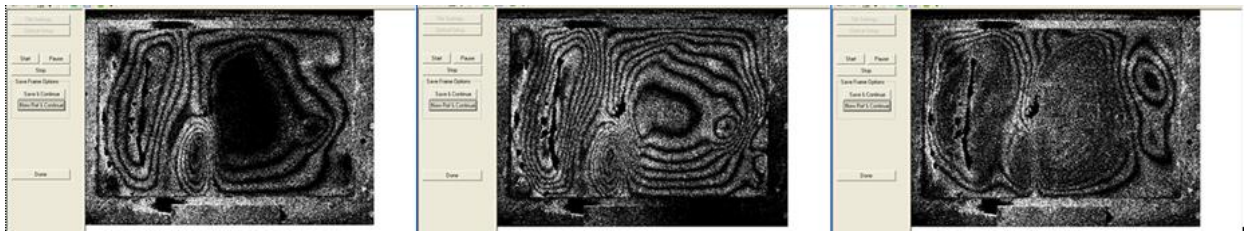
Results of experimental research are presented in Figs. 6-7. At the initial stage using the method of real time holographic interferometry temperature diapason of the heat source inside which thermal deformations of the data page holding frame were not observed was determined. Thus it remained stable and had no influence on deformations of the page. Further investigations were performed in this temperature diapason. Environment temperature during experimentation was in the range of 20-21°C. At the next stage an influence of the page holding frame on the character of the surface deformations was analysed. From the data of the interferograms obtained with varied clamping force which can be adjusted by nuts *3* (Fig. 5) it was determined that the data page should be fixed in the frame uniformly clamping all its sides. In such case it is sufficient to observe deformation of the page surface only in normal direction. Uniform pre-stressing of the nuts was achieved with the help of dynamometric wrench. As only qualitative assessment of the obtained results (deformation character of the page and its relative value are defined by location shape and density of interference fringes on the page surface) is to be performed deformation direction (in the direction of laser object beam or in the heat source direction) of the page was not determined.

In Fig. 6, a, b, c interferograms of the reference data page of Lithuanian passport obtained during experimental research are presented. The character of its deformation with respect to the holding frame sides due to heating reveals even distribution in normal direction of the page surface of close loop shaped interference fringes. The character of the location of the interference fringes with temperature growth of the supplied heat flow remains the same, just density of the fringes change. There is no interference fringes at the sides of the holding frame, what confirms that neither temperature change nor fixation of the page have any influence on the obtained results and are optimally chosen. There are no other indicators of deformations, therefore it can be stated that structure of the page is homogeneous with no qualitative damages. Such location of interference fringes can be considered as the reference one.



a b c

Fig. 6 Deformation interferograms of the reference data page of the passport of Republic of Lithuania as observed on the monitor of holography system PRISM. a) interferogram of normal deformation of the page when temperature of the applied heat flow is 24.5 - 25°C and heating duration is 4 s; b) interferogram of normal deformation of the page when temperature of the applied heat flow is 26 – 26.5°C and heating duration is 4 s; c) interferogram of normal deformation of the page when temperature of the applied heat flow is 29.5 - 31°C and heating duration is 4 s



a b c

Fig. 7 Interferograms of the falsified data page of passport A of the Republic of Lithuania. Applied temperature regimes are the same as for interferograms in Fig. 6

In Fig. 7 interferograms of the falsified data page of passport A of the Republic of Lithuania are presented. They were obtained under the same conditions of experimentation as were applied for the reference passport. Location and shape of the obtained interference fringes is obviously different if compared with the ones of reference passport pages. The zones of face image and data recording are damaged due to delamination of polycarbonate layers, mechanical removal of the primary data, new data recording and subsequent non even joining of the layers. Due to these reasons physical and mechanical properties of the data page were changed what led to the change of heat conduction properties at different zones of the page and together non even expansion of the page in normal direction. In the obtained interferograms three separate locations of close loop shaped interference fringes at the zones of face image and personal data recording can be observed. These zones practically do not change their location with temperature increase of the thermal load, but the observed change in density and shape of the fringes provides information on the character of growing deformation of the page in normal direction to its surface. The interferograms a, b, c in Fig. 7 are arranged in ascending order of the heat flow temperature.

4. Conclusions

1. The proposed metodology for MPR data page

authenticity nondestuctice verification based on the influence of heat expansion properties on its surface deformation which are visualized by the methods of high resolution holographic interferometry can be applied for primary inspection of travel documents.

2. A holding frame ensuring even fixing of the data page of a passport along its sides was designed.

3. The performed experimental research of MPR data page by non destructive testing methods of holographic interferometry and selecting thermal loads on the data page and its fixing conditions enabled to determine optimal surface deformation shapes of the MPR data page which can serve as the reference for surface deformation analysis of the other inspected passports.

References

1. **Daniel Weber** 2008. Optimization of human border control – requirements for supporting technology systems. EU Symposium. The EU Aquis with regard to document security, Spindulys, 454 p.
2. State Border Guard Service activities. 1995-2012 Statistics <http://www.pasienis.lt> accessed: 2013 July 1.
3. Regulation (EC) No. 444/2009 of the European Parliament and of the Council of 28 May 2009
4. 7th Pan European High Security Printing Conference <www.vdtat.gov.lt/files/pranesimas%20spaudai.pdf> accessed: 2013 July 1.
5. 8th Pan European High Security Printing Conference <http://www.vdtat.gov.lt/files/pranesimas_spaudai_2011.pdf> accessed: 2013 July 1.
6. Machine Readable Travel Documents. <www.icao.int/publications/Documents/9303_p1_v1_cons_en.pdf> accessed: 2013 July 1.
7. Technical specifications of polycarbonate films "MAKROFOL"<http://www.polymery.ru/letter.php?n_id=4801> accessed: 2013 July 1.
8. **Greičius, S.; Daniulaitis, V.; Vasiliauskas, R.; Pilkauskas, K.; Jūrėnas, V**. 2012. Structural integrity verification of polycarbonate type personal identity documents, Mechanika 18(2): 239-244. http://dx.doi.org/10.5755/j01.mech.18.2.1570.
9. **Vasiliauskas, R**. 2012. Opportunities of application of methods holographic interferometry for criminalistics researches, Public Security and Public Order: Scientific Articles [Elektronic edition] 7: 271-290.
10. **Janušas, G.; Jutas, A.; Palevičius, A.; Žižys, D.; Barila, A.** 2012. Static and vibrational analysis of the GMAW and SMAW joints quality, Journal of Vibroengineering 14(3): 1220-1226.

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ASMENS TAPATYBĘ PATVIRTINANČIO DOKUMENTO AUTENTIŠKUMO TYRIMAI HOLOGRAFINĖS INTERFEROMETRIJOS METODAIS

R e z i u m ė

Pastaraisiais metais sparčiai didėjant valstybės sieną kertančiu asmenų skaičiui labai aktualu yra nustatyti šių asmenų tapatybės dokumentų autentiškumą. Todėl labai svarbiu tampa tiek žmogiškojo faktoriaus, tiek tinkamų techninių priemonių ir naujų metodų, leidžiančių aptikti dalinius pakeitimus dokumente ar visiškai klastotą dokumentą, taikymas pirminiam dokumentų tikrinimui vaidmuo. Šis darbas skirtas asmens tapatybės dokumento – paso duomenų lapo autentiškumo tyrimams paremtiems neardančios kontrolės - holografinės interferometrijos metodais ir nustatant paso duomenų lapo šiluminio plėtimosi įtaką jo paviršiaus deformacijai. Atlikti eksperimentiniai tyrimai su originaliais ir suklastotais pasais, nustatytos duomenų lapo įtvirtinimo sąlygos specialiame laikiklyje, nustatyti temperatūrinio apkrovimo parametrai. Gauti tyrimų rezultatai holografinių interferogramų pavidalu patvirtino iškeltos hipotezės teiginius, kad suklastotų pasų duomenų lapo paviršiaus deformacijos akivaizdžiai skiriasi nuo originalių pasų duomenų lapų. Gauti eksperimentiniai rezultatai patvirtina galimybę taikyti pasirinktą neardančios kontrolės tyrimo metodiką pasų autentiškumui nustatyti.

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AUTHENTICITY ANALYSIS OF PERSONAL IDENTITY DOCUMENTS BY THE METHODS OF HOLOGRAPHIC INTERFEROMETRY

S u m m a r y

In recent years, when rapid growth of the number of people crossing state borders is observed it is very important to identify the authenticity of identity documents. Therefore it is becoming very important the impact of both the human factor and the role of application of appropriate technical measures and new methods on the possibility to detect partial changes in the document or forged in whole documents at the stage of primary inspection. This research is dedicated to the identity document - passport data page authenticity tests which are based on non-destructive testing - holographic interferometry methods and the determination of passport data page thermal expansion effect on the surface deformation. Tests were performed with original and forged passports, the data page fixing conditions in a special holder, and thermal load parameters were determined. The obtained results in the form of holographic interferograms confirmed the hypothesis claims that surface deformation of the data page in counterfeit passport is clearly different from the original passport's data page. The obtained experimental results confirm the possibility to apply the selected non-destructive testing methodology for determining authenticity of the passports.

Keywords: MRP data page, thermal expansion, thermal load, holographic interferometry, surface deformation.

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