ПУБЛИКАЦИЈЕ АСТРОНОМСКЕ ОПСЕРВАТОРИЈЕ У БЕОГРАДУ
PUBLICATIONS OF THE ASTRONOMICAL OBSERVATORY OF BELGRADE
Св. 102 No. 102

31st Summer School and International Symposium on the Physics of Ionized Gases

Belgrade, Serbia,
September 5 - 9, 2022

CONTRIBUTED PAPERS

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ABSTRACTS of INVITED LECTURES, TOPICAL INVITED LECTURES and PROGRESS REPORTS

Editors:
Dragana Ilić, Vladimir Srećković,
Bratislav Obradović and Jovan Cvetić

БЕОГРАД
2022

PUBL. ASTRON. OBS. BELGRADE No. 102, 1 - 302 BELGRADE, AUGUST 2022

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Belgrade, 2022

PUBLICATIONS OF THE ASTRONOMICAL OBSERVATORY OF BELGRADE

FOUNDED IN 1947

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Director of the Astronomical Observatory: Dr. Gojko Djurašević

Typesetting: Tatjana Milovanov

Internet address http://www.aob.rs

ISSN 0373-3742
ISBN 978-86-82296-02-7

Number of copies / tiraž : 200
Production: Skripta Internacional, Mike Alasa 54, Beograd

CIP - Каталогизација у публикацији - Народна библиотека Србије, Београд

537.56(082)
539.186.2(082)
539.121.7(082)
533.9(082)

SUMMER School and International Symposium on the Physics of Ionized Gases (31 ; 2022 ; Belgrade)

Contributed papers & abstracts of invited lectures, topical invited lectures and progress reports / 31st Summer School and International Symposium on the Physics of Ionized Gases - SPIG 2022, September 5-9, 2022, Belgrade, Serbia ; editors Dragana Ilić ... [et al.]. - Belgrade : Astronomical Observatory, 2022 (Beograd : Skripta Internacional). - 302 str. : ilustr. ; 24 cm. - (Publications of the Astronomical Observatory of Belgrade, ISSN 0373-3742)

Na nasl. str.: University of Belgrade, School of Electrical Engineering; University of Belgrade, Faculty of Physics; Serbian Academy of Sciences and Arts. - Tiraž 200. - Str. 17-18: Preface / editors Dragana Ilić ... [et al.]. - Bibliografija uz svaki rad. - Registar.

ISBN 978-86-82296-02-7

1. Ilić, Dragana, 1978- [уредник] [аутор додатног текста]

а) Јонизовани гасови – Зборници б) Атоми – Интеракција – Зборници в) Плазма – Зборници

COBISS.SR-ID 72751881

SPIG 2022

PREFACE

This special issue of the Publication of Astronomical Observatory in Belgrade (PubAOB) contains the contributed papers and abstracts of Plenary Lectures, Topical Invited Lectures and Progress Reports that will be presented at the **31st International Symposium on the Physics of Ionized Gases (SPIG 2022)** which will be held from 5th to 9th September 2022, in Belgrade, Serbia. The SPIG 2022 is organized by the University of Belgrade – Faculty of Physics, University of Belgrade – School of Electrical Engineering and Serbian Academy of Sciences and Arts, with the support of the Ministry of Education, Science and Technological Development of the Republic of Serbia. The 4th workshop on X-ray and VUV Interaction with Biomolecules in Gas Phase (4th XiBiGP), organized in collaboration with the SOLEIL synchrotron (France) will be attached to the SPIG 2022 conference.

Due to the ongoing COVID 19 pandemic, which is still affecting all our activities, and especially causing additional challenges for travels and meetings, the Organizing Committees of the SPIG 2022 conference have decided that the conference will be organized in a blended format, which allows participants to choose between virtual and regular (on-site) attendance. We expect to have virtual and regular participants, who will present 8 plenary invited talks, 18 topical invited, 21 progress reports, and 53 contributed papers (posters) within the main SPIG 2022 conference, and 17 invited talks within the XiBiGP workshop, from mainly four disciplines connected with physics of ionized gasses which have strong interactions in numerous applications: Atomic Collision Processes, Particle and Laser Beam Interactions with Solids, Low Temperature Plasmas and General Plasmas.

The SPIG reflects the progress in plasma physics and related fields. The conference has a long tradition, with the first meeting that was organized in Belgrade in 1962 under the title: ”1st Yugoslav Symposium on the Physics of Ionized Gases” (SPIG). This issue of

PubAOB presents new results in the fundamental and frontier theories and technology in the area of general plasma physics (including astrophysical and fusion plasmas), atomic collision processes and particle and laser beam interactions with solids.

Editors would like to thank the members of the Scientific and Advisory Committees of SPIG 2022 for their efforts in proposing the invited lectures and reviewing the contributed papers, as well as to thank the authors for their contribution and support to this Publication, and to wish all participants a pleasant and productive stay in Belgrade. We are grateful to the Serbian Academy of Sciences and Arts for their long term commitment to support this event as well as the Serbian Ministry of Education, Science and Technological Development for their continuing support.

Editors:
Dragana Ilić, Vladimir Srećković,
Bratislav Obradović and Jovan Cvetić,

Belgrade, August 2022

Publ. Astron. Obs. Belgrade No. 74 (2022), 219 - 222 *Contributed Paper*

ANALYSIS OF PRINTED CIRCUIT BOARD LIBS DATA USING DEEP LEARNING

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Abstract. The laser-induced breakdown spectroscopy (LIBS) is a method often used for monitoring the selective removal of thin layers by laser. In this way it is possible to achieve rapid prototyping of printed circuit boards. We show that it is convenient to use deep learning algorithm on LIBS data to obtain an indication that copper layer is fully removed.

1. INTRODUCTION

Rapid prototyping of printed circuit boards can be achieved by laser ablation. One of the possible approaches to this process was presented in Rabasovic et al. 2016. We have used the laser-induced breakdown spectroscopy (LIBS) as a convenient method both for ablation and for monitoring the selective removal of thin layers by laser. In Rabasovic et al. 2016 the LIBS data were analyzed by using correlation coefficients. Nowadays, availability of more and more fast computers, capable of machine learning, moves the analysis algorithms from simple numerical calculation towards the more sophisticated artificial intelligence methods. Our initial efforts for machine learning analysis of LIBS printed circuit board data, using principal component analysis are presented in Sevic et al. 2020. Interesting applications of machine learning algorithms for analysis of LIBS data are presented in Boucher et al. 2015, Moros et al. 2013, Serranoa et al. 2014. State of the art approaches to the problem are reviewed in Porızka et al. 2018, Vrabel et al. 2020; Zhang et al. 2022. In this paper we study the spectral data by using the deep learning algorithm.

2. ARTIFICIAL NEURAL NETWORKS AND DEEP LEARNING

Artificial neural networks (ANNs) mimic the human brain through a set of algorithms. They consist of input layer, hidden layers and output layer. A neural network that consists of more than three layers can be considered a deep learning algorithm, or a deep learning network.

Because of increasing computer efficiency more and more sophisticated machine learning algorithms become extensively used. The data set of certain structure is used to "train" the machine to learn some specific characteristics of input data. Then, machine could be used to recognize and identify these characteristics in newly presented

data of similar structure and nature.

3. EXPERIMENTAL SET-UP AND METHODS

Our experimental setup is and its applications for elemental analysis using LIBS, including several ways of processing spectra, are described in detail in Rabasovic et al. 2012, Rabasovic et al. 2014, Rabasovic et al. 2019, Sevic et al. 2011. The data analyzed here were obtained by experimental setup described in Rabasovic et al. 2016; at that time we have calculated the correlation coefficients of measured spectra to identify the moment of achieving the full removal of copper layer by laser ablation. In Sevic et al. 2020 we have implemented the PCA to achieve automatic recognition of the instant when laser ablation of copper layer has been finished and the laser starts damaging the composite substrate of printed circuit board. Here, to achieve the same goal, we use deep learning network. We use Solo + MIA software package (Version 9.0, Eigenvector Research Inc, USA).

4. RESULTS AND DISCUSSION

Plasma breakdown optical spectra of printed circuit board at the start, when only copper is ablated; and when the substrate is fully exposed, are shown in Fig. 1. Their differences could be seen by a naked eye.

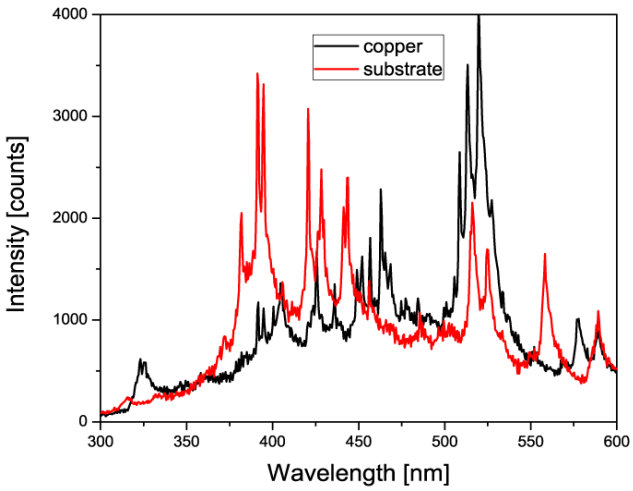

Figure 1: Plasma breakdown optical spectra of printed circuit board at the start, when only copper is ablated; and when the substrate is fully exposed.

At the beggining of the ablation process the peaks observed were neutral Cu lines at 510.55, 515.32, 521.82, and 578.21 nm. The prominent line was Cu I at 521.82 nm.

The presence of characteristic emission lines corresponding to the substrate was an indication to restrict the ablation zone and minimize the damage to the substrate. Any of the prominent lines such as Al I (394.39 nm, 396.19 nm), Ca I (422.64 nm, 616.2 nm), Ca II (393.43, 396. 88 nm), and Na I (589.15 nm) can be used as an indicator of the substrate.

We have trained the deep learning neural network with measured spectra corresponding to ablation of copper layer with 10, 50, 200 and 500 laser shots. We have adopted that output of network should produce the numbers between 1 and 100, corresponding very roughly to percent of laser ablation of copper. If output is higher of, say threshold of 90, then the laser shots should be stopped on that spot and laser beam should be moved further.

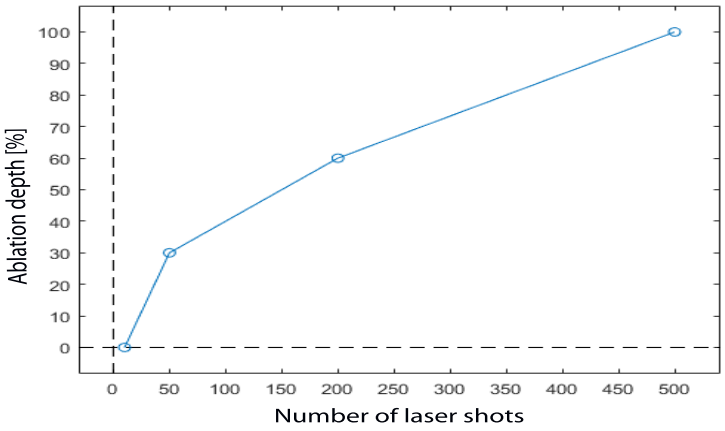

Figure 2: Training of deep neural network.

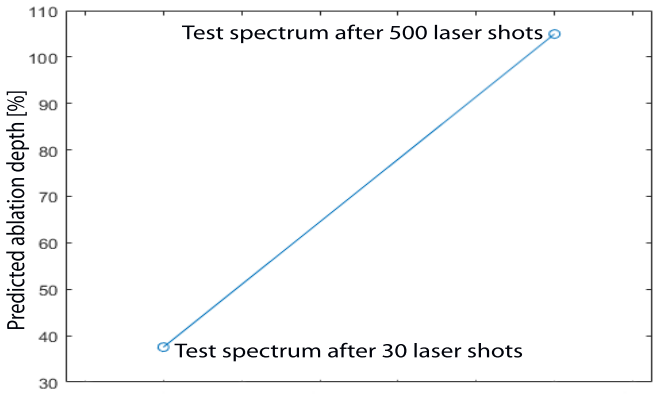

Figure 3: Two tests of trained deep neural network.

We have tested the network with spectra not presented before to the computer; and as expected, the predicted ablation level corresponded roughly to the functional dependence shown in Fig. 2. Two examples are shown in Fig. 3.

5. CONCLUSION

Rapid prototyping of printed circuit boards can be achieved by using laser ablation and LIBS. We have analyzed the LIBS data of printed circuit board by using deep learning algorithm. In our previous analyses we have used the correlation coefficients and PCA to identify the moment when laser ablation reaches the composite substrate of printed circuit board. Now, we have shown that it is possible to automatically detect the instant when the copper layer is fully ablated by deep learning network.

Acknowledgment

This work was financially supported by the Institute of Physics Belgrade, through the grant by the Ministry of Education, Science, and Technological Development of the Republic of Sebia

References

Boucher T.F., Ozanne M.V., Carmosino M.L., Dyar M.D., Mahadevan S., Breves E.A., Lepore K.H., Cleggc S.C. : 2015 *Spectrochimica Acta Part B* **107** 1.

Ann. Acad. Sci. Fennicae. Ser. A. I. Math.-Phys. **37** 1.

Loeve, M. : 1948 *Processus stochastiques et mouvements Browniens, Paris: Gauthier-Villars.*

Moros J., Serrano J., Gallego F.J., Macıas J., Laserna J.J : 2013 *Talanta* **110** 108.

Porízka P., Klus J., Hrdlicka A., Kepes E., Prochazka D., Hahn D.W., Kaiser J.: 2017 *J. Anal. At. Spectrom.* **32**, 277.

Rabasovic M.S., Sevic D., Pejcev V., Marinković B.P. : 2012 *Nucl. Instrum. Meth. B* **279**, 61.

Rabasovic M.S., Marinković B.P., Sevic D. : 2014 *IEEE Transactions on Plasma Science* **42**, 2388.

Rabasovic M.S., Sevic D., Lukac N., Jezersek M., Mozina J., Gregorcic P. : 2016 *Appl. Phys. A* **122**, 186.

Rabasovic M.S., Rabasovic M.D., Marinkovic B.P., Sevic D. : 2019 *Atoms* **7**, 6.

Serranoa J., Moros J., Sánchez C., Macías J., Laserna J.J : 2014 *Analytica Chimica Acta* **806** 107.

Sevic D., Rabasovic M.S., Marinkovic B.P. : 2011 *IEEE Trans. on plasma science* **39**, 2782.

Sevic D., Rabasovic M.S., Gregorcic P., Rabasovic M.S., Marinkovic B.P. : 2020 Publ. Astron. Obs. Belgrade No. 99, 117-120.

Vrabel J., Kepes E., Duponchel L., Motto-Ros V., Fabre C., Connemann S., Schreckenberg F., Prasse P., Riebe D., Junjuri R., Gundawar M.K., Tan X., Porízka P., Kaiser J. : 2020 *Spectrochimica Acta Part B* **169**, 105872

Zhang D., Zhang H., Zhao Y., Chen Y., Ke C., Xu T., He Y: 2022 *Applied Spectroscopy Review* **57** (2) 89-111.

The Workshop on X-ray and VUV Interaction with Biomolecules in Gas Phase (XiBiGP)

Publ. Astron. Obs. Belgrade No. 102 (2022), 287

EUROPEAN SYNCHROTRON AND FEL USER ORGANISATION: CURRENT CHALLENGES AND PROSPECTS (COST ACTIONS)

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Abstract. European Synchrotron and Free Electron Laser User Organisation (ESUO) represents all users of synchrotron and free electron-laser facilities in Europe, see ESUO webpage. At present, users from 31 European member states and European associated countries are represented by ESUO national delegates, among them is also a Serbian delegate who has been appointed by Optical Society of Serbia (OSS). In December 2018, the ESUO-Serbia has been established as a section of a National Organization of OSS. One of the major achievements of the ESUO-Serbia was an organization of the First ESUO Regional Workshop as a satellite meeting of the international conference *Photonica* held in Belgrade on 28th August 2019. Current challenges (e.g. the absence of Trans-National Access) and prospects of the ESUO (e.g. ESUO as a legal entity) will be discussed at this workshops, that is going to happened just after the 18th General Assembly of ESUO in SOLEIL synchrotron in August 2022. Also, some of the COST Actions related to the networking of a research preferentially done at synchrotron facilities will be reviewed.

Figure 1: ESUO official standard logo.

References

ESUO webpage: https://www.esuo.eu/
ESUO-Serbia webpage: http://uranus.ipb.ac.rs/~esuo-serbia/

SPIG 2022 PROGRAMME

Belgrade, Serbia, September 05 – 09, 2022

All indicated times are given in the Central European Summer Time (CEST) zone.

Monday 5th September 2022 **SPIG 2022 (day 1)**	
	XiBiGP Workshop
09:00-09:30	***Registration***
09:30-09:40	**Hall B: Opening and Introduction** Aleksandar Milosavljević and Christophe Nicolas (SOLEIL)
09:40-10:00	*European Synchrotron and FEL User Organisation: Current Challenges and Prospects (COST Actions)* **Bratislav Marinković**, Institute of Physics Belgrade, Serbia **[Regular]**
	***Session 1, Hall B**, Chair: Aleksandar Milosavljević*
10:00-10:20	*Ultrafast dynamics of photo-excited molecules at FERMI Free Electron Laser* **Michele di Fraia,** Elettra-Sincrotrone Trieste, Italy **[Virtual]**
10:20-10:40	*UV-induced processes in DNA* **Lara Martínez-Fernandez,** Universidad Autónoma de Madrid, Spain **[Virtual]**
10:40-11:00	*The 'LEGO bricks' of life: a gas-phase study of dipeptides* **Laura Carlini,** CNR-ISM, Italy **[Virtual]**
11:00-11:20	*Photofragmentation of the radiation therapy enhancers: can we make better ones?* **Marta Berholts,** Tartu University, Estonia **[Virtual]**
11:20-12:00	***Coffee break***
	***Session 2, Hall B**, Chair: Sergio Diaz-Tendero*
12:00-12:30	*Plasmon-induced chemical reactions on noble metal nanoparticles studied by synchrotron XPS and surface-enhanced Raman scattering* **Ilko Bald,** University of Potsdam, Germany **[Virtual]**
12:30-12:50	*Valence band structure of isolated biomolecule-functionalized gold nanoparticles* **Jelena Pajović,** Faculty of Physics, University of Belgrade, Serbia **[Regular]**
12:50-13:10	*Determination of the Adenine-Thymine binding energy* **Sebastian Hartweg,** Synchrotron SOLEIL, France **[Virtual]**
13:10-13:30	*In the search of peptide prebiotic building blocks: Studying the fragmentation of photoionized Diketopiperazines* **Darío Barreiro-Lage,** Universidad Autónoma de Madrid, Spain **[Regular]**
13:30-15:30	***Lunch break***
	***Session 3, Hall B**, Chair: Lucas Schwob*
15:30-16:00	*VUV and soft X-ray interactions with trapped biomolecular ions* **Thomas Schlathölter,** University of Groningen, Netherlands **[TBC]**
16:00-16:20	*Covalent bond formation within clusters: a pathway for the synthesis of complex molecules in the interstellar medium* **Yoni Toker,** Bar Ilan University, Israel **[Regular]**
16:20-16:40	*To be announced* **Kaja Schubert,** DESY, Germany **[Virtual]**
16:40-17:00	*X-ray absorption spectroscopy and mass spectrometry of protonated ATP molecule* **Aleksandar Milosavljevic,** Synchrotron SOLEIL, France **[Regular]**
17:00-17:30	***Coffee break***
	***Session 4, Hall B**, Chair: Christophe Nicolas*
17:30-18:00	*An overview on the recent liquid-jet PES developments* **Bernd Winter,** Fritz Haber Institute of the Max Planck Society, Germany **[Virtual]**

ACKNOWLEDGEMENT

31st SUMMER SCHOOL AND INTERNATIONAL
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is organized by

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