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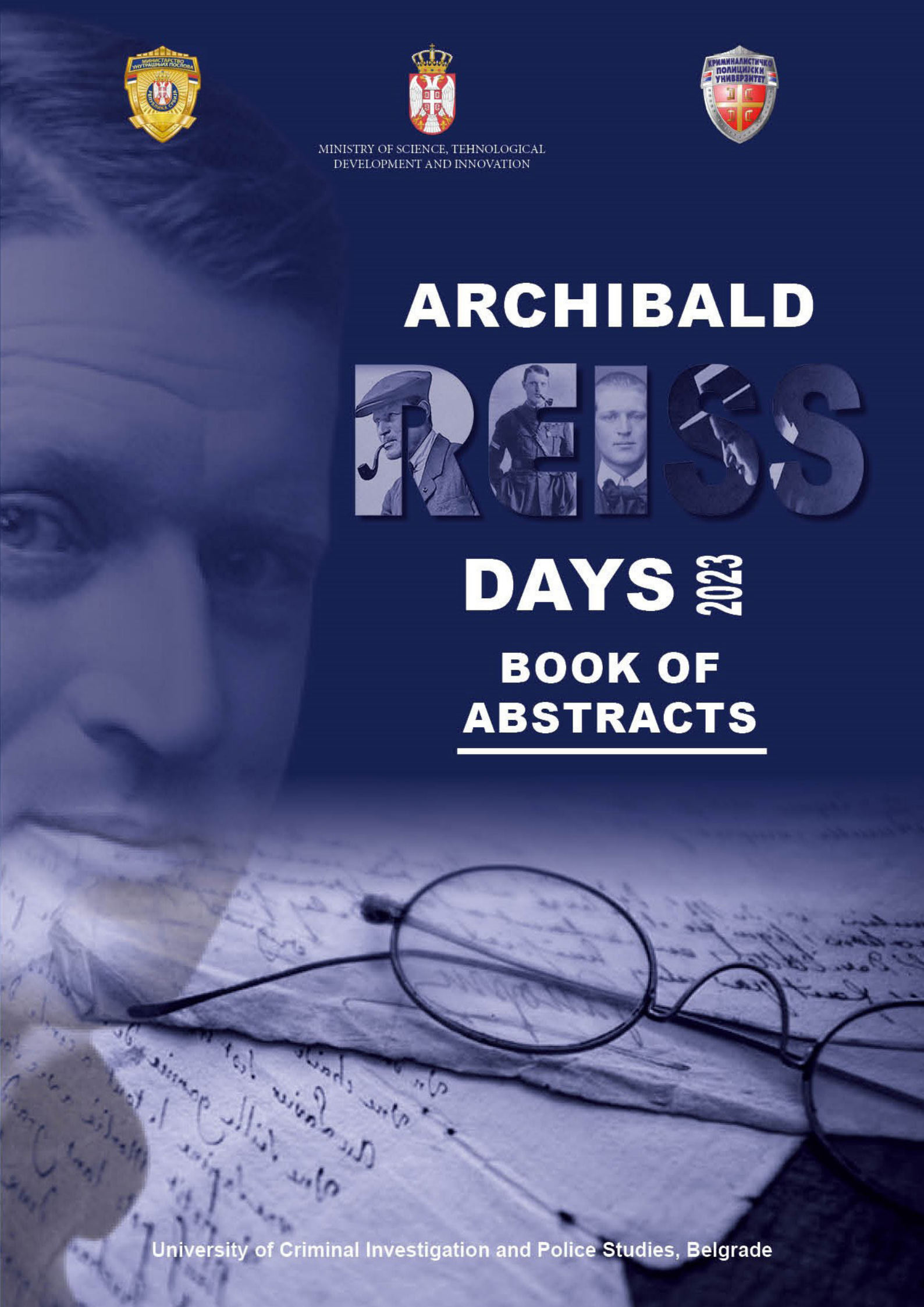

University of Criminal Investigation and Police Studies, Belgrade

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BOOK OF ABSTRACTS

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ANALYSIS AND INTERPRETATION OF BIMETALLIC PLASMONIC METAMATERIAL PROPERTIES FOR FORENSIC APPLICATIONS

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Purpose: Plasmonic biochemical sensors, as a subgroup of optical refractometric sensors, are a topic of rapid research and development due to their ability to detect trace amounts of biochemical agents, even allowing detection of a single molecule. As such, plasmonic sensors find wide applications in forensic engineering, medicine and clinical diagnostics, food processing, environmental protection, and many more. Additionally, the use of plasmonic metametrials is not limited to sensing, and they can be used in various fields paramount to forensic sciences, such as enhanced microscopy and spectroscopy, photodetector enhancement (entire optical range – UV, VIS, and IR light), signal processing, etc.

Design/Methods/Approach: In this experimental and numerical analysis, we present heterometallic multilayers consisting of alternating nickel and copper layers as a multipurpose metamaterial. Composite structures of nickel and copper films on a conductive substrate were fabricated by the electrochemical deposition (ED) technique using the dual-bath method. Optical properties were modeled using a 2D finite element method (FEM) with realistic material parameters in COMSOL Multiphysics® software. The mechanical properties of the laminate structure were determined using the microindentation method.

Findings: Based on the obtained results, we determined an increase in the composite hardness value of the laminated structure, and through numerical simulation, we confirmed the rich spatial and spectral optical behavior favorable for use in biochemical sensing and photodetector enhancement.

Originality/Value: In addition to rich optical behavior due to plasmonic effects, our proposed structure is also a metamaterial with improved mechanical and corrosion resistance properties. Copper possesses excellent plasmonic properties in conjunction with its low cost, especially when compared to other plasmonic materials such as gold or silver. Thus, improvements in mechanical properties not only increase the general robustness of the structure but also translate directly into achieving high optical functionality at a low cost.

Keywords: electrodeposition, dual-bath, composite hardness, plasmonics, finite element method, metamaterials.

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Ivana Mladenović, PhD, focuses on experimental and theoretical research in the fields of material science and composite structures. Her main research fields are electrochemical deposition and characterization of metallic composite structures, with particular focus on metallic laminates and thin solid films and their structural-morphological and mechanical characterization. Since recently, she has been involved in the optimization of synthesis parameters for electrodeposition using various optimization software tools and the prediction of material mechanical responses via artificial neural networks.

Marko Obradov, PhD, focuses on theoretical and experimental research in the fields of photonics and plasmonics. His work includes the design and development of broadband optical superabsorbers and antireflective structures, the utilization of novel and alternative plasmonic materials, the application of plasmonics for enhanced light harvesting, and plasmonic structures for biochemical sensors. He participated in both national and international projects.

Milena Rašljić-Rafajilović, PhD, focuses her research on the fields of microfluidics and TiO2 nanoparticle synthesis. She is an expert in the design and fabrication of microreactors from Si/Pyrex glass and PDMS materials for nanoparticle synthesis. Dr. Rafajilović's skills also include the design and fabrication of various types of sensors and actuators, piezoresistive pressure sensors, photodiodes, and the integration of graphene with PDMS-based polymers.

Zoran Jakšić, PhD, is a retired principal research fellow. More than 35 years of research experience. The fields of interest are nanooptics and nanophotonics (including plasmonics and metamaterials), sensors, infrared photodetectors, MEMS (including microreactors), and NEMS. He led several international projects and subprojects, including EU-funded projects. He actively pursues his research work in spite of being physically disabled.

Olga Jakšić, PhD, has more than 25 years of research experience. Her fields of interest are research and development of micro/nanosystems (MEMS and NEMS), adsorption and desorption processes in plasmonics, metamaterials, MEMS and NEMS characterization, AI-assisted MEMS/NEMS design, and multiscale modeling.

Dana Vasiljević Radović, PhD, has more than 25 years of research experience. The fields of interest are research and development of micro/nanosystems (MEMS and NEMS) sensors and platforms (including microreactors), optics and plasmonics, and also AFM characterization of materials, surfaces, and MEMS/NEMS components. Within the many national and international projects she led, more than 10 PhD students completed their theses.

Jelena Lamovec, PhD, focuses her interest in the field research and application of microelectronic technologies in the manufacture of semiconductor components, research in the field of chemical and electrochemical applications, deposition of thin films on metal and semiconductor substrates, examination of the micromechanical properties of materials and MEMS structures as hybrid composites, and research in the field of mechanochemical methods for obtaining nanoparticles of various materials by application of the high-energy planetary mill. Newer research also includes the application of materials for forensic purposes.