

**Application form for research topics  
in the field of engineering and technology  
for candidates to the Doctoral School  
in the academic year 2024/2025**

Proposed subject matter of a doctorate
<b>Testing the mechanical and tribological properties of the surfaces of tools, machine parts and biomaterials made of stainless steel with coatings deposited by PVD techniques</b>
Scientific discipline ( <i>delete as appropriate</i> )
<del>AUTOMATION, ELECTRONICS, ELECTROTECHNICS AND SPACE TECHNOLOGIES</del> <del>CIVIL ENGINEERING, GEODESY AND TRANSPORT</del> MECHANICAL ENGINEERING
Proposed doctoral thesis supervisor
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Brief description of the research topics with an indication of the scientific issues (max. 350 words)
<p>Stainless steels are widely used for cutting tools, machining tools, measuring tools, rolling bearing elements, springs, parts exposed to abrasion and surgical tools [1]. In the case of tools, the requirements usually concern high elasticity, strength, stiffness, sharpness of cutting edges, high wear resistance and good corrosion resistance. Martensitic stainless steels exhibit moderate corrosion resistance compared to austenitic steels. Passive layers on these steels are particularly susceptible to destruction in aqueous chloride solutions, which can cause surface damage in the form of pitting and stress corrosion. Due to low hardness and poor tribological properties, austenitic stainless steels have limited use in conditions of intense friction wear.</p> <p>In the last few decades, there has been significant progress in material surface engineering, including the technology of producing coatings using CVD (Chemical Vapor Deposition) and PVD (Physical Vapor Deposition) methods. The use of single-layer or single-phase coatings often no longer sufficiently meets the requirements related to the durability and reliability of machine parts, tools or biomaterials. Therefore, technologies are currently being developed to produce multi-component coatings with a multi-layer, gradient or nanostructured structure. In order to fulfill their purpose, anti-wear coatings should have an appropriately selected number of parameters, including: chemical and phase composition, structure, thickness, surface smoothness, hardness, low coefficient of friction, and above all, demonstrate good adhesion to the base material. Among the PVD techniques used to modify the surface of products, the most commonly used is arc evaporation or reactive magnetron sputtering, which usually require heating of the coated substrates, which is a limitation related to the risk of</p>

tempering of the steel. An example of techniques that can ensure a low deposition temperature with high plasma ionization during the process may be magnetron sputtering (HIPMS) or cathodic arc evaporation with additional current pulses.

In the technological laboratories of the Faculty of Mechanical Engineering, it is possible to develop and deposit coatings using several PVD techniques. Devices and advanced research equipment are also available to analyze the chemical and phase composition as well as to characterize the mechanical, tribological and corrosion properties.

1. Ram Subbiah at all, Materials Today Proceedings 2019, Volume 18, Part 7, pp. 2802-2805 (<https://doi.org/10.1016/j.matpr.2019.07.146>)

Justification of the purposefulness of taking up the research topics (max. 150 words)

Design and production, using PVD methods, of carbon or carbide-based transition metal carbonitride coatings on stainless steels, which can be applied to tools used in the paper industry, tools for processing polymers and composites, or medical tools and instruments. The coatings should have special properties - primarily good adhesion to the substrate, resistance to cracking, resistance to abrasive wear and good corrosion resistance in the environment of their use. The desired modification of the surface of stainless steel will be achieved by producing coatings using the cathodic arc evaporation technique with additional current pulses and/or the reactive magnetron sputtering technique. These techniques are characterized by relatively low temperatures during technological processes, which may allow the production of coatings on stainless steels without fear of changing their structure and properties as a result of tempering.

Proposed topics of doctoral theses within the proposed research subject matter ( up to 3 topics)

1. The influence of manufacturing parameters using the reactive magnetron sputtering technique on the tribological properties of metal carbide and carbonitride coatings produced on austenitic stainless steels substrates
2. Tribological properties and corrosion resistance of medical steel with a martensitic structure with carbon coatings produced by cathodic arc evaporation in terms of applications for surgical tools and instruments.

The sources of financing of the research topics (the subject matter of currently implemented research grants financed from external sources or as part of subsidies)

1. Development of deposition technology zirconium-based coatings on Ni-Ti alloy tools and their operational tests. Project of the Koszalin University of Technology financed by a subsidy for the discipline of Mechanical Engineering, Koszalin 2023. (project manager).
2. Design of anti-wear ZrNC coatings for NiTi alloys produced by 3D printing. Project of the Koszalin University of Technology financed by a subsidy for the discipline of Mechanical Engineering, Koszalin 2023. (contractor).

Confirmation of the possibility of ensuring access to scientific apparatus and software necessary for the realization of the proposed research topics (*delete as appropriate*)

FULLY/ PARTIALLY/ NONE

If the answer is PARTIALLY or NONE please indicate a type of missing scientific apparatus and/or software and the sources of financing an access to them

Transmission electron microscope (HR-TEM), electron spectrometer (XPS) - submission of NSC PRELUDIUM project and scientific cooperation with other centers.

List of the supervisor's scientific achievements in the field of indicated scientific problems
A list of up to 5 major supervisor's publications related to the proposed research topics, published in journals indexed in the Web of Science or Scopus for the period of the last 3 years (taking into account the IF Impact Factor and the MNiSW score)
<ol style="list-style-type: none"> <li>1. Lukaszewicz K., Sondor J., Paradecka A., Pawlyta M., Chmiela B., Pancielejko M., Szczucka-Lasota B., Węgrzyn T., Tański T., Structure and Tribological Properties of AlCrN + CrCN Coating. <i>Coatings</i> 10 (2020) 1084. (<a href="https://www.mdpi.com/2079-6412/10/11/1084">https://www.mdpi.com/2079-6412/10/11/1084</a>) – IF = 2.881, MNiSW score = 100 pt.</li> <li>2. Węgrzyk S., Herman D., Pancielejko M., High-strength glass-ceramic from ZABS system modified with transition metal oxide, <i>Journal of Non-Crystalline Solids</i>, 582 (2022) 121443. (<a href="https://doi.org/10.1016/j.jnoncrysol.2022.121443">https://doi.org/10.1016/j.jnoncrysol.2022.121443</a>) – IF5 = 3.78, MNiSW score = 70 pt</li> <li>3. Ratajski J., Bałasz B., Mydlowska K., Pancielejko M., Laskowska D., Szparaga Ł., Phase transformations in Ni-rich additively manufactured NiTi alloys, <i>Journal of Achievements in Materials and Manufacturing Engineering</i>, Phase transformations in Ni-rich additively manufactured NiTi alloys, <i>Journal of Achievements in Materials and Manufacturing Engineering</i> 121/1 (2023) 118-130. DOI: <a href="https://doi.org/10.5604/0.3001.0054.3215">https://doi.org/10.5604/0.3001.0054.3215</a>) – IF = no, MNiSW score = 140 pt.</li> </ol>
A list of research grants financed by the National Science Centre, the National Centre of Research and Development and the European Research Council for the period of the last 5 years
"IMSKA-MAT Innovative dental and maxillofacial implant scaffolds manufactured using innovative additive technology supported by computer material design ADD-MAT" - Project POIR.01.01.00-0397/16-00 co-financed by the European Union Smart Growth Operational Program, implemented in 2017-2021 at the Design, Research and Production Center for Medical and Dental Engineering Asklepios sp. zoo in Gliwice. (contractor).
A list of research services provided for industry related to the proposed research topics for the period of the last 5 years
Pancielejko M. - project entitled: "Testing of the microstructure of 6 areas of damage to a cast iron elbow and preparation of a test report" - commissioned by Forum Koszalin Sp. z o. o., ul. Przeskok 2, 00-032 Warszawa. Implementation period 29/03-02/04/2021. Faculty of Mechanical Engineering, Koszalin University of Technology. Project manager.