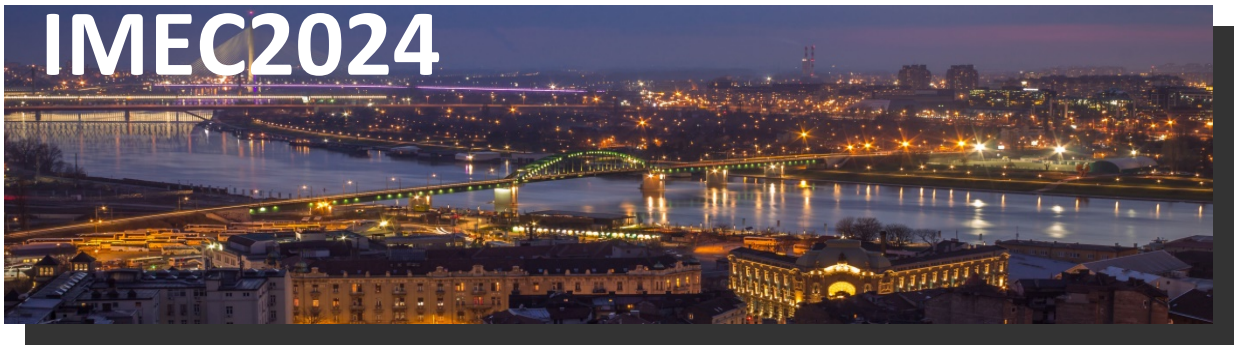
# 2nd International Conference on Innovative Materials in Extreme Conditions




# PROGRAM

# and

# BOOK OF ABSTRACTS

**20-22 March 2024**

**Belgrade, Serbia**

# 2nd International Conference on Innovative Materials in Extreme Conditions

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# and

# BOOK OF ABSTRACTS

**20-22 March 2024**

**Belgrade, Serbia**

**Program and Book of Abstracts of the 2nd International Conference on Innovative Materials in Extreme Conditions (IMEC2024)** publishes abstracts from the field of material science, physics, chemistry, earth, and computational science on the phenomena arising during the processing and/or exploitation of the innovative materials, which are presented at the international conference on innovative materials in extreme conditions.

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## *Preface*

*Dear conference participants and readers, we have the pleasure to welcome you all to Belgrade, Serbia, as the venue for the 2nd International Conference on Innovative Materials in Extreme Conditions (IMEC2024). This event is jointly organized by the Serbian Society for Innovative Materials in Extreme Conditions (SIM-EXTREME), the Center of Excellence "Center for Synthesis, Processing and Characterization of Materials for Application in Extreme Conditions - CEXTREME LAB" of the Vinča Institute of Nuclear Sciences - National Institute of the Republic of Serbia, University of Belgrade, and the Faculty of Mechanical Engineering, University of Belgrade.*

*The scope of the IMEC2024 is to become the worldwide forum for discussion of experts and young researchers on the phenomena arising during the processing and/or exploitation of the innovative materials. The IMEC2024 conference is focused on the current research in the field of material science, physics, chemistry, earth, and computational science. Experimental and computational investigations of materials obtained or operated under extreme conditions presented during the conference are highlighting recent progress in the development of the innovative materials at high pressures, under high magnetic and electric fields, over a wide range of temperatures, radiation conditions, corrosive environments, under extreme mechanical loads, and non-equilibrium thermodynamic conditions. The interrelation between external effects, microstructural characteristics, and material properties is considered on the experimental and theoretical level to obtain new or enhanced insights into the material behavior and their application.*

*We want to use this opportunity to thank our sponsors and co-organizers for helping us to successfully organize the IMEC2024 conference. First of all, we want to mention that the Ministry of Science, Technological Development and Innovation of the Republic of Serbia recognized our conference as an important event and gave their financial endorsement. Also, we want to thank the Vinča Institute of Nuclear Sciences – National Institute of the Republic of Serbia, University of Belgrade, for their strong financial support. We especially appreciate the support of the Royal Family of Serbia and the Serbian Royal Palace. In the end, we would like to thank all the members of the Conference Advisory Board, the Conference International Scientific Committee, and the Conference Organizing Committee who participated in the preparations of the IMEC2024 conference.*

*Editors*

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| **SESSION A**<br>**Session Chairs:**<br>***Branko Matović, University of Belgrade, Serbia***<br>***Ivana Cvijović-Alagić, University of Belgrade, Serbia*** | |
| **9:30 – 10:00**<br>**Plenary Lecture** | *Pavol Šajgalik, Slovak Academy of Sciences, Slovakia*<br>Rapid hot-pressed silicon carbide ceramics for ultra-high temperature applications |
| **10:00 – 10:20**<br>**Invited Lecture** | *Tetiana Prikhna, National Academy of Sciences of Ukraine, Ukraine*<br>The high-temperature applicability of the Ti,Nb-Al-C MAX phases-based bulk materials and vacuum-arc deposited films |
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| **14:00** | **Conference closing ceremony** |

# The high-temperature applicability of the Ti,Nb-Al-C MAX phases-based bulk materials and vacuum-arc deposited films

**T.A. Prikhna[1], T.B. Serbenyuk[1], O.P. Ostash[2], V.B. Sverdun[1], A.S. Kuprin[3], B. Matović[4], I. Cvijović-Alagić[4], V.Ya. Podhurska[2]**

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[2]*Karpenko Physical-Mechanical Institute of the National Academy of Sciences of Ukraine, Naukova St. 5, 79060 Lviv, Ukraine*

[3]*National Science Center Kharkov Institute of Physics and Technology, Akademicheskaya St. 1, 61108 Kharkov, Ukraine*

[4]*Vinča Institute of Nuclear Sciences – National Institute of the Republic of Serbia, University of Belgrade, Mike Petrovića Alasa 12-14, 11000 Belgrade, Serbia*

The MAX phases of the Ti-Al-C system show promising characteristics for high-temperature wear-resistant applications due to their lightweight, electro-conductive behavior, and high damping and low friction abilities. During the present research the bulk $Ti_2AlC$, $Ti_3AlC_2$, and $(Ti,Nb)_3AlC_2$ were developed and their characteristics, as promising materials for the production of solid hydrogen fuel cells interconnects, pantograph, and damping substrates, were examined.

The porous $Ti_3AlC_2$ material was synthesized by hot pressing under low 15 MPa pressure. A significant reduction of wear of the copper substrate was achieved when $Ti_3AlC_2$ was applied. Namely, during friction in pair with copper its wear resistance in comparison with traditionally used Silumin was 40 times higher, and the wear of copper was 50 times smaller. Moreover, $Ti_3AlC_2$ demonstrated much higher arc resistance than Silumin. Moreover, the produced 5-μm-thick $Ti_3AlC_2$-based films, that were deposited on the Ti substrate using a vacuum-arc method from the hot-pressed target, showed extremely promising characteristics for the high-temperature applications, in particular for interconnects fuel cells and as cavitation-resistant coatings on turbines. Namely, the obtained testing results showed that after heating at 600 $^oC$ for 1000 h the deposited films surface electrical conductivity only slightly decreased from 0.01°Ω to 0.01-3°Ω while the surface of pure Ti after 250 h in the same regime was completely oxidized and lost its conductivity.

On the other hand, during the conducted investigation it was established that the resistance to fretting fatigue at room temperature of the samples with deposited 13.3-μm-thick coating based on the $Ti_2AlC$ MAX phase is almost 5 times higher when compared with the samples without coating, *i.e.* 324,000 load cycles *vs* 67,000 cycles. Namely, the wear study at 500°C of the samples with a deposited coating based on the $Ti_2AlC$ MAX phase showed significantly better wear-resistant behavior than in the case of the uncoated sample. During the mentioned testing at the initial stage the coefficient of friction, $\mu$, increased to the same value ($\mu = 0.42$) for both sample types, however, for the uncoated sample it continued to increase over time contrary to the coated sample behavior where $\mu$ value remained stable. A significant difference was also observed in the friction track profiles: for the coated sample the friction track was quite uniform with the track depth of 3 μm, while in the case of the uncoated sample the local ridges were observed in the 7-μm-deep track. Furthermore, the specific wear rate parameter, $W$, turned out to be almost 2 times higher for the samples without deposited coating ($W=2.35\times10^{-3}$ $mm^3/Nm$) than for the samples with $Ti_2AlC$ coating ($1.27\times10^{-3}$ $mm^3/Nm$).

Results of the present research indicated that the films obtained from the target with added Nb, *i.e.* $(Ti,Nb)_3AlC_2$ films, are characterized by slightly lower wear resistance than those obtained from the target based on MAX phases without Nb.

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