REVIEW

by Assoc. Prof. PhD Aleksandar Tsanev,
Institute of General and Inorganic Chemistry – BAS,
member of the scientific jury
regarding the competition for the academic position of "Associate Professor"
in professional field 4.2 "Chemical Sciences",
scientific specialty "Solid State Chemistry",
announced in the Official Journal of the Republic of Bulgaria
No. 58, p. 190, announcement No. 182 dated June 26, 2026

regarding the competition for the academic position of "Associate Professor" in professional field 4.2 Chemical Sciences (Solid State Chemistry) for the needs of the "Design and Characterization of Catalytic Materials" Laboratory at the Institute of Catalysis – BAS (IC-BAS), announced in the Official Journal of the Republic of Bulgaria, No. 58, p. 190, announcement No. 182 dated June 26, 2026; candidate: Assistant Professor Evgeni Petrov Popov

Reviewer: Assoc. Prof. Dr. Alexander Svetoslavov Tsanev, Institute of General and Inorganic Chemistry – BAS, member of the scientific jury

This review has been prepared pursuant to Order No. RD-09-42 dated August 28, 2026, issued by the Director of the Institute of Catalysis – BAS, based on the decision of the Scientific Council of the IC-BAS (Minutes No. 11 dated November 19, 2025), regarding the selection of an Associate Professor for the competition announced in the State Gazette (DV) No. ... 58, p. 190, dated 26 June 2026. The sole candidate in the competition for the academic position of "Associate Professor" is Assistant Professor Evgeni Petrov Popov from the "Design and Characterization of Catalytic Materials" Laboratory at the Institute of Catalysis – BAS.

1. Opinion on the submitted materials:

The set of materials submitted to me in electronic format contains all the necessary documents described in the Regulations on the Conditions and Procedure for Acquiring Scientific Degrees and Occupying Academic Positions at the Institute of Catalysis – BAS. Assistant Professor Evgeni Petrov Popov meets the conditions specified in the Regulations. A list comprising a total of 59 scientific works is attached; the competition entry includes 19 scientific works that do not duplicate the publications submitted for the acquisition of the Educational and Scientific Degree of "Doctor" (PhD). Eight publications are designated as equivalent to a habilitation thesis; of these, five are ranked Q1, one is Q2, and one is Q4. One publication has an SJR ranking. Another 11 original scientific works fully meet the requirements of the current procedure.

The summary of compliance with the criteria set forth in Article 44 of the Regulations on the Conditions and Procedure for Acquiring Scientific Degrees and Holding Academic Positions at the Institute of Catalysis – BAS shows that the candidate exceeds the minimum requirements for each indicator: for Indicator B (Indicator 3 or 4) – 167 points out of the required 100; for Indicator G (sum of Indicators 5 through 10) – 275 points out of the required 200; and for Indicator D (Indicator 11) – 166 points out of the required 60. The candidate enters the competition with a total of 658 points, against a requirement of 430 points.

Biographical data and professional development:

Assistant Professor Evgeni Petrov Popov completed his studies at the Faculty of Physics of Sofia University "St. Kliment Ohridski" between 1995 and 2006, specializing in "Physics of the Atomic Nucleus and Elementary Particles."He obtained the academic degree of Doctor of Physics between July 2008 and July 2013 at the Institute for Nuclear Research and Nuclear Energy – BAS; the title of his dissertation was "Modeling the interaction of positrons in condensed matter used in ITER." At the Institute for Nuclear Research and Nuclear Energy of the Bulgarian Academy of Sciences, he held the following positions: Physicist (March 1, 2007 – July 3, 2008), Assistant (July 25, 2011 – July 22, 2015), and Assistant Professor (July 23, 2015 – July 1, 2025), working in the field of positron spectroscopy. Since March 2018, he has held the position of Senior Researcher at the Joint Institute for Nuclear Research (JINR)—located at 6 Joliot-Curie St., Dubna, Russia—specifically at the Frank Laboratory of Neutron Physics, working in the fields of positron spectroscopy and neutron diffraction. Since July 2025, he has held the position of Assistant Professor at the Institute of Catalysis of the BAS.

3. Analysis of the candidate's scientific and applied scientific activity:

a. Scientific publications

The total list of publications submitted by Assistant Professor Evgeni Popov for the competition comprises 19 articles. These include 59 scientific papers, the majority of which have been published in journals indexed by Scopus or Web of Science. No evidence of plagiarism was found regarding any of the submitted publications. The publications submitted for the competition do not duplicate those used to obtain the educational and scientific degree of "Doctor" (PhD). The results of the candidate's research activities have been published in authoritative international journals, with 24 publications falling into the Q1 category (WoS or Scopus). There are 12 publications in the Q2 category and a total of 12 in the Q3 and Q4 categories; consequently, the majority of the publications co-authored by Assistant Professor Evgeni Popov appeared in Q1 and Q2 journals.

In accordance with the Regulations on the Conditions and Procedure for Acquiring Academic Degrees and Holding Academic Positions at the Institute of Catalysis (IC–BAS), the publications submitted for the competition are divided into two groups corresponding to indicators B and G. The first group—indicator B, "Habilitation work: scientific publications in journals refereed and indexed in world-renowned scientific databases (WoS or Scopus)"—comprises 8 publications.

A total of 11 publications are presented under indicator G-7, all of which appeared in Q1 journals.

The minimum required points for the position of "Associate Professor" in this group are 220; thus, the candidate has fully met the minimum requirements for the position.

Impact of scientific publications:

The significant impact of Assistant Professor Evgeni Popov's publications in the scientific literature demonstrates the scientific value of his work. His publications have been cited 83 times (Group D – Citations in scientific journals, monographs, edited volumes, and patents refereed and indexed in world-renowned scientific databases such as Web of Science and Scopus). This result exceeds the minimum requirement of 60 points for the position of "Associate Professor" by nearly threefold, underscoring the high scientific value of his work.

In summary, based on the submitted materials, the candidate – Assistant Professor Evgeni Popov – exceeds the established requirements for the position of "Associate Professor" across all scientometric indicators, in accordance with the *Regulations on the Conditions and Procedure for Acquiring Scientific Degrees and Holding Academic Positions at the Institute of Catalysis – BAS*. He has accumulated a total of 658 points, surpassing the minimum requirement of 430 points. 4. Evaluation of the candidate's scientific and applied scientific contributions:

4. Assessment of the candidate's scientific and applied scientific contributions:

The scientific publications included in Group B (Habilitation Thesis) – specifically those in journals refereed and indexed in world-renowned scientific databases (WoS or Scopus) – total eight; notably, the majority appear in Q1 journals. The primary scientific contributions arising from the fundamental and applied research of Assistant Professor Evgeni Popov lie in the application of techniques such as positron annihilation spectroscopy, neutron diffraction, X-ray diffraction, and Raman spectroscopy, among others – methods applicable to the study of catalytic systems and catalysis in general. This research can be unified under the overarching theme of investigating the degradation of ultra-high-temperature ceramic and nanostructured coatings designed for use in nuclear reactors and space technologies. In nuclear and thermonuclear systems, the degradation of these materials is induced by high-energy neutrons, helium nuclei, and fast heavy ions interacting with plasma-facing materials. Concurrently, in outer space, structural components are exposed to galactic cosmic rays and solar proton events. A common and critically destructive factor in both contexts is high-intensity volumetric gamma radiation. Gamma photons generate stresses and defects (atomic displacements) throughout the bulk of materials via Compton scattering and the photoelectric effect. This leads to the formation of vacancies, clusters, and transmutation-induced changes that disrupt structural homogeneity, degrade mechanical properties, and reduce thermal conductivity. The candidate's scientific contributions are categorized into three groups:

1. Analysis of radiation defects resulting from ion irradiation in materials for reactor and space applications [Publications B1, B4, B5, B6, B7].

2. Analysis of radiation defects resulting from gamma irradiation in materials for reactor and space applications [Publications B2, B3].
3. Engineering approach to adapting a cryogenic device for investigating structural and magnetic phase transitions via neutron diffraction [Publication B8].

Group 1

Contribution Group 1 comprises publications focused on the analysis of defects arising from ion irradiation in materials intended for reactor and space applications. The materials investigated include tungsten as well as materials coated with tantalum and an iron-chromium alloy; the iron-chromium alloy-coated materials are intended for the fabrication of structural components. Positron spectroscopy studies compared the behavior of the two types of coatings; it was found that tantalum coatings exhibited an increase in positron lifetime to ~400 ps – with He absorption reducing the lifetime more significantly than H_2 absorption – whereas Fe-Cr coatings showed an increase in both positron lifetime and electron momentum. These changes correlated with vacancy size, the H/He atom ratio, and the chromium content of the matrix. Assistant Professor Evgeni Popov took a keen interest in the behavior of W_2B-type systems – suitable for the construction of thermonuclear reactor first walls – following light-ion irradiation. To this end, a $W_x(Ta,V,Cr,Ti)_y$ alloy was investigated; the alloy demonstrated self-healing capabilities and excellent surface stability under He^+ irradiation. At an energy of 200 keV, the $W_{0.5}(Ta,V,Cr,Ti)_{0.5}$ alloy exhibited a hardness increase of 3.3 GPa compared to pure W, while forming only bubble precursors and dislocations. Quaternary systems lacking Ti (W-[Ta,V,Cr]) demonstrated exceptional resistance to heavy-ion bombardment (Kr^+, Cu^+) and minimal radiation hardening. The addition of 4 wt.% Ti, in turn, has shown a beneficial effect on the relative density and hardness of the matrix. It has also been found that carbide alloying in tungsten-titanium alloys and pure tungsten has a beneficial effect on their properties – specifically high hardness, thermal stability, and the preservation of the matrix's electrical conductivity. Low-energy He^+ irradiation intensified surface nanostructuring (pore formation) in the TiC phase, whereas the W-TiC (1.1 wt.%) alloy demonstrated enhanced resistance to irradiation-induced defects under 1 MeV Kr^+ bombardment (at both room temperature and 1173°C) due to the recombination of radiation defects. It was also shown that under high-energy He+ ion irradiation (3 MeV), systems containing 0.25–0.8 wt.% TiC exhibit up to ten times greater resistance to surface damage compared to pure W.

Tungsten borides (W_xB_y) have long been recognized as excellent materials for radiation shielding, combining high hardness and thermal conductivity with the ability to attenuate neutrons and gamma rays; however, producing them in monolithic form presents a number of challenges. For this reason, synthesizing WC-WB-W_2B composite systems posed a challenge for Assistant Professor Evgeni Popov. W, B_4C, TiC, and carbon were used as precursors for their synthesis, with the materials being mixed via mechanical alloying and subsequently sintered at 1750°C. Tungsten diboride was investigated as a highly promising material due to its established superior thermodynamic stability at high temperatures. Assistant Professor Evgeni Popov undertook this study to address the lack of experimental data regarding the material's behavior under irradiation. The research filled this gap by evaluating structural damage in the synthesized W_2B. The study also examined the effects of light and heavy ion irradiation – relevant to the International Thermonuclear

Experimental Reactor (ITER) – on another material in this class of compounds: B_4C. B_4C samples were irradiated with high-energy heavy ions at room temperature; structural changes were analyzed using XRD, while defect evolution during hydrogen and helium implantation was predicted through positron lifetime calculations. XRD analysis revealed an increase in lattice parameters due to the filling of interstitial sites, as well as partial amorphization of the structure. The observed grain fragmentation following irradiation was assessed as a favorable factor for the subsequent natural sintering of the base components within the reactor. Minimal changes in electron density accompanying the increase in volumetric defects confirmed the good radiation resistance of B_4C and its suitability for use in thermonuclear systems.

Research paper [B5] investigated the behavior of the commercial carbide Widia-N (WC-6Co) under Xe ion irradiation. The results demonstrated that the accumulated energy causes structural changes affecting both the surface and the bulk in distinct ways. Surface alterations include the breaking of W–O bonds, accompanied by reduction processes, non-monotonic changes in carbon cluster size, and facilitated penetration of atmospheric N_2 into the carbon matrix. It was found that exceeding a xenon ion fluence threshold of 10^{13} ions/cm² leads to the complete amorphization of the graphite-like phase. Due to their larger atomic volume, W atoms are more easily displaced by Xe ions than C or Co atoms; this triggered the formation of new carbon-rich phases (WC_2, W_2C_5) or secondary cobalt-containing phases (WC_2 + x wt.% Co, where $x > 6$).

Bulk changes were characterized by a steady increase in internal compressive stress as the irradiation dose increased. While the primary δ-WC phase remained stable—showing no overall bulk phase transition—induced point defects reorganized into dislocations, primarily within the carbon sublattice. Positron annihilation data revealed that positron trapping occurs at small vacancy clusters and grain boundaries, with the generation of new grain boundaries confirmed at the highest irradiation fluences.

Group 2

Group 2 comprises publications focused on the analysis of radiation-induced defects in materials intended for reactor and space applications following gamma irradiation. Research was conducted on ZrB_2, a material characterized by high electrical and thermal conductivity, resistance to chemical and mechanical wear, resistance to chemical and radiation-induced corrosion, and a high melting point, properties that make it exceptionally suitable for use under extreme conditions. Its resistance to radiation exposure was investigated by assessing the quantity of defects induced by irradiation. It was found that gamma irradiation in unannealed samples caused the formation of zirconium monovacancies and the expansion of vacancy clusters. Annealing further transformed the material by reorganizing point defects, resulting in the migration of monodefects and clusters toward surface regions. Although the annealed samples reached stoichiometric equilibrium, the functional properties that had originally made the material a promising candidate were lost following the final dose of gamma irradiation. However, an increase in positronium annihilation intensity was observed at the maximum gamma-irradiation dose. Study B3 examines TiN as a candidate material for use under extreme conditions, aiming to analyze changes in the defects present within TiN nanoparticles. To this end, Doppler broadening and positron annihilation lifetime spectroscopy methods were employed. The study also investigated the effects of annealing at

1373 K, using a 24-hour temperature cycle, both before and after irradiation. Analysis of the material revealed that, as the dose increased, the population of titanium monovacancies gave way to vacancy clusters comprising both titanium and nitrogen vacancies. An increase in both the concentration and volume of large vacancy clusters was observed. At high doses, a general migration of large vacancy clusters toward grain boundaries was noted.

Group 3

Publications in Group 3 describe an engineering approach to adapting a cryogenic device for investigating structural and magnetic phase transitions via neutron diffraction.

This work resulted in the development of an efficient cryostat for low-temperature neutron diffraction measurements, capable of maintaining the sample temperature below 2 K for extended periods.

The author's summary of the work of Asst. Prof. Evgeni Popov builds upon his habilitation research. It encompasses 11 scientific publications investigating the behavior of radiation-exposed materials, specifically focusing on their corrosion resistance. A notable material among these is ZrB_2, known for its radiation tolerance in highly dynamic and radiation-intense environments. As a candidate material for the first wall of thermonuclear reactors and for aerospace components, it underwent detailed testing involving heavy-ion and gamma-ray irradiation combined with thermal treatment. The research revealed fundamental differences in the material's damage mechanisms depending on the radiation source. While irradiation with fast heavy ions led to structural degradation, gamma photons caused significantly lower bulk amorphization, amounting to just 1.2% at a maximum dose of 3000 kGy, as well as a dose-dependent lattice volume expansion reaching a maximum of 0.011 Å. This process was accompanied by the formation of mono- and divacancies (V_{Zr}, V_B) and vacancy clusters.

The behavior of ZrB2 under thermal exposure also varied depending on the material's initial state. Heating between 373 K and 773 K resulted in linear expansion of the crystal lattice, driven by the dissociation of surface OH^- groups and water molecules. This resulted in the release of reaction products such as $Zr(OH)_4$, H_3BO_3, and H_2. However, annealing at 1173 K following gamma-induced damage activated a specific "self-healing" mechanism in the ceramic, occurring without phase transitions or additional oxidation. An increase in the crystalline order of the material under study was observed, alongside the preservation of its high mechanical stability.

It has been demonstrated that the identified self-healing mechanism preserves the structural integrity of ZrB_2 and extends its service life, making it an excellent choice for reactor first-wall applications—including within advanced ZrB_2–SiC composites or hybrid architectures involving liquid metals.

In study [G5], nanocomposite films consisting of high-density polyethylene and silicon dioxide were investigated as candidates for radiation shielding and insulation under high-dose gamma irradiation. It was confirmed that SiO_2 nanoparticles suppress defect formation by filling

micro-voids and trapping positrons at interfacial boundaries, thereby reducing the formation of ortho-positronium.

It has also been shown that tungsten composite materials alloyed with vanadium carbide (W-6wt%VC-1wt%C) exhibit improved relative density, hardness, wear resistance, and high thermal stability compared to pure tungsten. In addition, positron-based analysis indicates that subsequent vacuum annealing for five hours at 1000°C leads to effective relaxation and the recovery of the majority of bulk vacancy-type defects in the composite.

The multi-scale structural evolution and radiation tolerance of W-Ni heavy alloys under 2.5 MeV He^+ ion irradiation were also investigated. The results revealed that, despite the collision cascades initiated, the majority of displaced atoms rapidly recombine into the lattice, preventing the accumulation of stable Frenkel pairs. Multi-scale analysis showed that the system's radiation tolerance stems not from a complete absence of damage, but rather from the high recombination rate and the capacity of interphase boundaries to act as defect sinks. To effectively serve as a region for accommodation and defect absorption, the Ni4W phase must be finely and discontinuously dispersed within the structure, rather than present as coarse, continuous regions. In practice, this requires precise control of the Ni content and powder metallurgy parameters, including mixing homogeneity, sintering schedules, cooling rates, and post-sintering heat treatment. The influence of silicon and niobium alloying additions, as well as the C/N ratio, on the structural-phase composition, neutron activation, and electrochemical corrosion behavior of multicomponent carbonitride coatings, specifically nanocrystalline CNTi-(Zr, ZrNb, and ZrSi) type coatings deposited via the cathodic arc method onto Ti_6Al_4V titanium alloy and 316L stainless steel substrates at a controlled C/N ratio of approximately 0.5, was investigated. The objective was to achieve superior protective performance in aggressive environments. It was found that the incorporation of silicon into the TiZrSiCN matrix leads to a drastic improvement in the corrosion resistance of the coatings, whereas alloying with niobium (TiZrNbCN) at a level of approximately 5.5 at% promotes localized pitting corrosion and reduces the overall corrosion resistance of the system. Following intensive fast-neutron irradiation, it was determined that none of the investigated coatings underwent long-term radioactive activation; furthermore, neutron flux bombardment had absolutely no effect on surface morphology, crystal structure, or layer thickness, thereby demonstrating their marked radiation resistance and the absence of structural deformation under these critical operating conditions.

Study G7 investigates the effect of high hydrostatic pressure on the structure and physicochemical-mechanical properties of composite ceramics with the composition Al_2O_3+nYSZ (n = 0, 1, 5, 10, 15 wt.%), produced from powders containing metastable θ- and γ-Al_2O_3 phases. Experimental results demonstrated that optimal physicochemical-mechanical properties were achieved with compositions containing 10% and 15% YSZ (annealed at 1000°C), compressed at 700 MPa, and sintered at 1550°C for 2 hours. Regarding defect formation, aluminum vacancies were observed in all samples, with the incorporation of 10% and 15% YSZ promoting the generation of larger defect clusters.

5. Reviewer's personal impressions of the candidate:

Although I do not have personal impressions or direct observations of the work of Assistant Professor Dr. Evgeni Popov, judging by his research activities and the results achieved, it can reasonably be concluded that he is an established researcher with a clearly defined specialization and a significant contribution to his scientific field at an international level. His work is distinguished by a high degree of precision, depth of analysis, and consistency in his research approach. His research outputs demonstrate an ability for independent thinking, critical evaluation of the issues at hand, and the application of a systematic methodology that enables the formulation of well-reasoned, substantiated, and convincing conclusions.

The originality of his research endeavors is particularly striking, as is his commitment to achieving results of high scientific value and practical applicability. The contributions of Assistant Professor Dr. Evgeni Popov hold both fundamental and applied significance; they not only expand existing scientific knowledge and enrich the respective research field but also pave the way for developing new solutions to important practical problems. In this regard, his work has the potential to contribute to the advancement of the scientific community and to the improvement of the quality of life through the practical application of scientific achievements.

Based on these factors, I regard Assistant Professor Dr. Evgeni Popov as a researcher possessing high scientific competence, a distinct professional profile, and significant achievements in his field. His research output and the resulting contributions merit high praise and recognition, including within an international context. I am convinced that such achievements demonstrate the significance of his research work and its potential to exert a lasting positive impact on the advancement of both science and practice.

6. Critical remarks and recommendations regarding the candidate's scientific works:

The candidate's scientific works submitted for the competition fall entirely within the thematic area of "Solid-State Chemistry," and more specifically, "Design and Characterization of Catalytic Materials." The submitted habilitation thesis and summary of achievements provide an excellent overview of the candidate's work. The results are significant both for science and for the design of new catalytic materials; beyond their scientific value, they also hold potential for direct practical application in industry. I have one question for the candidate: How do the increase in the lattice parameter and the amorphization of the material enhance its radiation resistance? As a critical observation or recommendation, it would have been beneficial for the candidate to provide a list of the conferences in which they participated, given that some of the listed publications are conference papers. This would have served as an additional albeit/not mandatory indicator of the dissemination of their research within the scientific community.

CONCLUSION: The documents and materials submitted by Assistant Professor Evgeni Petrov Popov meet all the requirements of the Act on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its application, and the relevant Regulations governing the conditions and procedures for acquiring scientific degrees and occupying academic positions at the

Institute of Catalysis – BAS. The candidate has submitted a sufficient number of scientific works published subsequent to the materials used for his PhD defense and his appointment to the position of Assistant Professor. The results of Assistant Professor Popov's research activities represent original scientific contributions that fully meet and significantly exceed the Institute of Catalysis – BAS requirements for the research output of candidates for the academic position of Associate Professor in the relevant field. **I support the candidacy and confidently recommend that the members of the Scientific Jury and the esteemed Scientific Council of the Institute of Catalysis – BAS appoint Assistant Professor Evgeni Petrov Popov to the academic position of Associate Professor in professional field 4.2 "Chemical Sciences" ("Solid-State Chemistry")**.

13.10.2026.
Sofia

Prepared the review: . . . . . .
(Assoc. Prof. PhD. Aleksandar Tsanev,
member of the scientific jury)