Habilitation Thesis Resume

Advanced Micro and Nanostructured Materials for biomedical applications: Synthesis, Processing, Applications and Advanced Characterization

Candidate: Bogdan Stefan VASILE – PhD.eng. since 2011, at this moment Scientific Researcher II

Scientific Context and Relevance

This habilitation thesis consolidates an extensive and coherent research activity dedicated to the design, synthesis, processing, and advanced characterization of micro- and nanostructured materials for biomedical applications. The research addresses critical challenges in modern materials science, particularly the demand for biocompatible, multifunctional, and antimicrobial materials capable of improving clinical outcomes in implantology, wound management, and tissue regeneration

The scientific relevance of the work is strongly aligned with international research priorities in nanomedicine, biomaterials engineering, and advanced functional materials, responding to global issues such as antimicrobial resistance, implant-associated infections, and the need for regenerative medical solutions.

Candidate Profile and Scientific Maturity

The candidate, Bogdan Ștefan Vasile, PhD (Chemical Engineering), is a Senior Researcher II at POLITEHNICA Bucharest and holds multiple leadership roles within national research infrastructures. He is the Head of the Advanced Structural Analysis and Electron Microscopy Laboratory at the National Research Center for Micro and Nanomaterials (CNMN) and serves as Technical Manager of the same center. Additionally, he coordinates laboratories within the Research Center for Advanced Materials, Products and Processes (CAMPUS) and is a member of its Scientific Board

The candidate demonstrates advanced scientific independence and leadership, evidenced by his coordination of national and international research projects, management of state-of-the-art research facilities, and sustained involvement in strategic research planning. His expertise is particularly strong in transmission electron microscopy (TEM) and related techniques (STEM, EDX, EELS, EFTEM), acquired through specialized training at prestigious international institutions

Scientific Contributions

Silver-Based Micro- and Nanomaterials: A major contribution of the thesis lies in the development of silver nanoparticle–based biomaterials with enhanced antimicrobial functionality.

The candidate demonstrated original approaches for incorporating silver into hydroxyapatite matrices, polymeric systems, and textile-based wound dressings, while preserving structural integrity and biological compatibility.

Silver-doped hydroxyapatite was synthesized via controlled co-precipitation at low temperature, maintaining the hexagonal apatite structure without secondary phases. Advanced structural analyses confirmed nanoscale crystallinity, uniform morphology, and successful ionic substitution. Biological assays on macrophage cell lines showed that silver incorporation enhanced antimicrobial potential while maintaining acceptable cytocompatibility, supporting the material's suitability for implant coatings

In parallel, PLA/AgNP composite coatings produced by Matrix-Assisted Pulsed Laser Evaporation (MAPLE) exhibited strong antibiofilm activity against Staphylococcus aureus and Escherichia coli. These coatings were shown to be non-cytotoxic for endothelial cells and capable of preventing microbial colonization on medical devices, directly addressing CNATDCU criteria related to applicability and societal impact

Advanced Hydroxyapatite-Based Nanomaterials: The thesis provides substantial contributions to the field of ion-substituted hydroxyapatite, including systems doped with europium and zinc. These materials were engineered to exhibit photoluminescent, antimicrobial, and osteoconductive properties, expanding the functional scope of hydroxyapatite beyond traditional bone replacement materials.

The work also includes the development of 3D-printed hydroxyapatite structures, demonstrating the candidate's capacity to integrate additive manufacturing with nanomaterials science. These results support CNATDCU indicators related to originality, interdisciplinarity, and technological transfer

Oxide-Based Biomaterials for Wound Healing: Another important research direction focuses on oxide-based nanomaterials, particularly doped ZnO systems (Co, Mn). The candidate established clear correlations between dopant chemistry, defect structure, and antibacterial efficiency. These materials were successfully applied in advanced wound dressings, showing enhanced antimicrobial performance and potential for skin tissue regeneration

This line of research demonstrates methodological rigor through the combined use of XRD, SEM, TEM, and biological assays, reinforcing the candidate's competence in advanced physico-chemical characterization, a key CNATDCU evaluation criterion.

Scientific Impact and Visibility

The scientific impact of the candidate's activity is substantial. The thesis documents over 330 publications in indexed journals, a high cumulative impact factor, an h-index of 46, and more than 6000 citations (excluding self-citations). The candidate is also the author or co-author of multiple patents and recipient of numerous international innovation awards, confirming both academic excellence and applied relevance.

Moreover, the candidate is a founding member and President of the Electron Microscopy Society of Romania, and an active representative in European microscopy organizations, demonstrating strong international visibility and networking capacity.

Direction of Development and Future Research Perspectives

In line with research expectations, the thesis clearly outlines future research directions, focusing on:

- Development of non-conventional synthesis routes for oxide and non-oxide nanomaterials;
- Functional gradient and multifunctional materials for biomedical applications;
- Nanostructured thin films with tailored electrical, magnetic, and biocompatible properties;
- Functionalization of nanoparticles with biologically active molecules;
- Expansion of 3D-printed biocompatible scaffolds for regenerative medicine

The candidate explicitly demonstrates the capacity to supervise doctoral research, supported by prior experience in guiding over 30 PhD candidates and by access to advanced research infrastructure.