Universitatea
Transilvania
din Brașov

HABILITATION THESIS

SUMMARY

Title: LASER WELDING AND SURFACE ENGINEERING OF ADVANCED MATERIALS

Domain: Industrial engineering

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The habilitation thesis entitled **Laser welding and surface engineering of advanced materials** provides a synthesis of the author's scientific results in the field of laser technology, starting from the obtaneing of the title of Doctor Engineer in the field of industrial enginering.

The thesis is written in English, comprises 124 pages, and is structured into 4 distinct sections: **B1 Professional achievements, B2 Scientific achievements, B3 Career evolution, and B4 Bibliography**.

The work begins with a brief presentation of the author's professional achievements in the field of industrial engineering after obtaining the PhD title in 2011. Laser processing technology is the main focus of the scientific research presented in this habilitation thesis, a field that naturally extends from the doctoral thesis titled *Research on Nd:YAG laser welding of stainless steel thin-walled components*, defended in 2011 at the Politehnica University of Bucharest, and the dissertation titled *Laser welding of austenitic stainless steel thin components*, defended in 2011 at the Tehnical University of Madrid.

Professionally, the author started her career in 2011 as a scientific researcher at SC Optoelectronica-2001 SA, Măgurele, where she worked until 2016 when she joined Transilvania University of Brașov, on the position of assistant professor. The first part of the thesis, titled **Professional achievements**, presents the evolution of the author's teaching career and research activities. She has been involved in 16 scientific research projects and has published numerous scientific articles, 41 of which are indexed in the Web of Science Core Collection.

The second section of the thesis, **B2 Scientific achievements**, is structured into 5 chapters and comprehensively addresses the field of laser processing technology. It details fundamental research on welding, laser cladding, texturing, and laser beam surface engineering of various conventional or advanced materials such as FeCrAl.

Chapter 1 of the thesis, titled *Theoretical foundations and motivation*, begins by presenting the motivation behind the habilitation thesis. The characteristics of electromagnetic radiation, whether originating from natural or artificial sources, form the foundation for using the laser radiation in diverse fundamental research within the industrial sector. Throughout the chapter, the concept of laser technology is gradually developed, and the main characteristics of electromagnetic radiation are presented.

Continuing, **Chapter 2**, titled *Processes using the laser beam*, describes the main laser processing methods used by the author in her scientific research activities. Among these, laser welding is one of the primary applications of lasers in the industry being detailed in this chapter. The principles of conduction welding and laser welding in the keyhole mode are fundamental concepts underlying the case studies presented throughout the work. Additionally, laser cladding and texturing are presented both conceptually and experimentally, including the author's own results on high-alloy powder depositions armed with tungsten carbide particles. At the end of this chapter, the concept of laser heat treatment in conjunction with laser surface melting is introduced, detailing the applications of this technique in the industry. The applicability of surface processing techniques, laser melting/remelting, to advanced materials such as FeCrAl intended for use in 4th generation nuclear power plants is emphasized. This chapter provides a comprehensive perspective on how the author has integrated various laser technology-based processes in relation to the relevant literature.

Chapter 3, *Experimental research on laser welding of stainless steel,* is dedicated to describing three experimental studies on laser welding of stainless steels. Optimization of parameters for laser welding of AISI 321 steels is achieved by determining the influence of laser power, pulse duration, and frequency on the geometry of the welded joint. The presented study results allowed for obtaining clear values regarding optimal process parameters for laser pulse welding in the millisecond range. The author's original contributions in this field are highlighted, including the obtaneing of heterogeneous weld joints between carbon steel and stainless steel (AISI 1010 - AISI 321). The study results showed that laser power, or power density, is the main parameter that influnece the distribution of chemical elements in the welded joint. According to the third study presented in this chapter, the weldability of stainless steels can be improved by using an active flux, such as SiO_2, to enhance the absorption of the laser beam. The research results in this chapter, disseminated in three scientific publications, allow for an objective evaluation of the laser technology's capability in fabricating welded joints between similar or different materials, using laser systems operating continuously or in a pulsed regime.

Chapter 4 presents scientific research in the field of laser surface processing of advanced materials such as FeCrAl. Laser surface melting and remelting are the author's proposed solution for increasing the corrosion resistance and hardness of FeCrAl alloys, especially those intended for use in 4th generation nuclear power plants. The results in this chapter are obtained through direct collaboration with the LAMET and ERAMET laboratories from the Politehnica University of Bucharest and the implementation of the project *Advanced metallic materials for new generations of nuclear power plants*, 4R, NUCLEARMAT (Contract PCCA 243/2014), for which the author was responsible.

Laser surface melting is a modern surface processing technique that involves microstructural and morphological modifications due to the melting/remelting of the material and the rapid heating-cooling cycle of the processed area. This processing technique forms the basis of the study presented in Chapter 5, titled *Advanced laser processing method in liquid*.

Chapter 5 describes an original laser surface processing technology using a liquid, enabling thermo-mechanical treatment combined with surface microalloying. The original concept presented in this chapter is based on the phenomenon of cavitation in a liquid, namely nickel acetate, and the obtained results validate the proposed technology. Cavitation in liquid, in this context, proves to be an innovative method for achieving thermo-mechanical processing and nickel microalloying of the processed surface.

The third section of the thesis, **B3 Career evolution**, presents the author's plans for the development of her teaching and research career. Continuous development of professional skills, the use of modern teaching-learning techniques, and the ongoing updating of courses are the author's main objectives in the evolution of her academic career.

The author's research activities will continue in the field of laser technology, and three future research directions are briefly described:

1. Determining a method for real-time monitoring of laser processing.
2. Heterogeneous welding of titanium with stainless steel.
3. Designing new materials of the High Entropy Alloy (HEA) type and laser surface processing.

The last part of the thesis, **B4 Bibliography**, presents the bibliographic references associated with this thesis.