Transilvania University of Braşov

HABILITATION THESIS

SUMMARY

Title: MULTIFUNCTIONAL THIN SOLID FILMS

Domain: Materials Engineering

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Summary

My PhD thesis, successfully defended in 2013, titled: "**Research on the synthesis and characterization of MeOxNy system thin films deposited by reactive magnetron sputtering**" presents the development of oxynitride-type thin films (MeOxNy, where Me = Ta), deposited by reactive magnetron sputtering. One of the most frequently used methods to alter the surface properties of a material is to deposit a thin film or coating on top of the base material, which will significantly improve the functionality of the final part, in terms of its mechanical, electrical, optical, chemical properties, and so on.

After the completion of the PhD program, my research had the main objective of improving the research on tantalum oxynitride thin films, by extending the studies towards the most promising application directions.

Moreover, I was involved in the research and development of several types of multicomponent thin films, evidenced in the majority of the ISI-WOS published articles: **45 ISI-WOS papers** (45 indexed, 40 in journals and 5 proceedings papers) and **14 BDI papers**. The thin film research and development, mainly by Physical Vapor Deposition (DC sputtering, pulsed laser deposition, High-power impulse magnetron sputtering (HiPIMS), etc.), was complemented by surface characterization (nanoindentation, wear and tribology, adherence of thin films to substrates, corrosion resistance, biocompatibility, photocatalysis, electrical, and optical analysis).

The habilitation thesis titled **Multifunctional thin solid films** represents the accumulation of knowledge in the field of surface engineering, based on my work with reactive magnetron sputtering deposition and several analysis techniques. The scope of this habilitation thesis is to show that reactive magnetron sputtering is a powerful technique which is able to obtain complex thin solid films, with multifunctional properties, which can be tailored to suit the desired application.

The first part of the habilitation thesis presents my professional track after the completion of my PhD program, with emphasis on the accomplishments and results.

The scientific results are presented in the following section, which is structured in four chapters. A short description of the content of each chapter is presented hereinafter.

Chapter one contains relevant information regarding the theoretical aspects of sputtering, some information on the role of the applied magnetic field, and key information regarding the reactive sputtering process, with emphasis on some factors that govern the stability and reproducibility of the reactive magnetron sputtering deposition.

Chapter two presents results obtained after the completion of my PhD program, on optimized tantalum oxynitride TaO_xN_y thin solid films, regarding certain possible applications: i) photocatalytic

behavior, observed through the photodegradation of some solutions of methylene blue, respectively methyl-orange, with or without hydrogen peroxide, under the action of the ultraviolet spectrum, respectively of the visible spectrum, in the presence of the tantalum oxynitride thin solid films; ii) as a material with tunable electrical properties, where the electrical resistivity increases with increasing reactive gas mixture partial pressure, starting from characteristic values of metallic compounds to characteristic values of oxides, and the high resistivity samples exhibit permittivity values up to 41, significantly higher than those for other tantalum-based films found in the literature; iii) as a potential biomaterial due to its adequate antibacterial/antibiofilm capacity against certain pathogens.

Chapter three presents results concerning the composition, morphological and mechanical characteristics for ceramic composite magnetron sputtered (Ti + TiB_2 + WC) coatings. The films were obtained by simultaneous standard/reactive magnetron sputtering from three targets (Ti, TiB_2 and WC). The films are hard (instrumented indentation hardness values between 20 and 22 GPa), but if they are deposited on softer materials, they exhibit poor adhesion to the substrate, which can be certainly improved by adjusting the deposition parameters. These films show promising results concerning their wear resistance, especially if the films would be paired with an appropriate substrate material.

Chapter four presents preliminary results concerning the development of single stage deposition ternary hard coatings with improved corrosion properties. The purpose of the research presented herein was to study refractory metal multiple component nitride-type thin films, obtained by simultaneous sputtering of two metallic targets, with the addition in various proportions of reactive gas. The refractory metal candidate was chosen after preliminary tests in respect to the corrosion behavior of the binary nitride coatings. The second stage of the research was to deposit multiple component coatings, and to analyze them in terms of corrosion protection capacity, but coupled with as high as possible mechanical properties.

The last section of this habilitation thesis presents the career development plan, related to teaching activities, as well as future research directions. The future research subjects are reliant on the gained knowledge since the completion of my PhD program. The proposed subjects are: **i)** developing complex oxynitride coatings, such as $Me_1Me_2O_xN_y$-type materials, which can be tailored to answer certain industrial requirements; **ii)** due to multiple unanswered questions regarding the coatings presented in chapter 4 of this thesis, the research activities will be devoted towards understanding the physical phenomena displayed by this system. Secondly, further research is planed using the same hypothesis, namely pairing two elemental targets, to obtain single stage corrosion resistant complex coatings; **iii)** the development of multiple component nitride-type compounds due to their potential original properties compared to their nitride parents.