Publishable executive summary

HARDECOAT - Contract no NMP3-CT-2003-505948

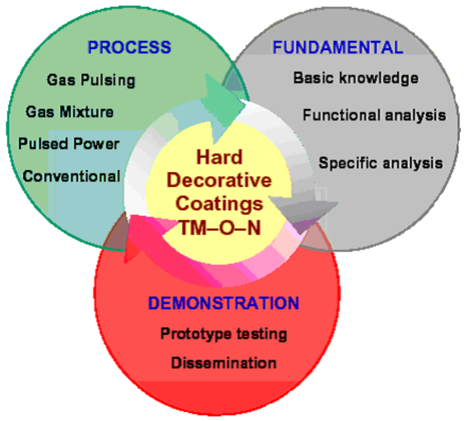
Development of new hard decorative coatings based on transition metal oxynitrides

Project objectives

The HARDECOAT project aims at developing **new functional coatings** for **decorative, protective** and **micro-optoelectronics applications**. The coatings based on **transition metal oxynitrides** (TM-O-N) are deposited by **physical vapour deposition** techniques, especially by reactive sputtering. The idea is **to combine** the excellent mechanical properties of the **nitrides** with specific optical characteristics of the **oxides**. By tuning the deposition conditions, coatings with **composition varying from oxides to nitrides** are reached, exploring the unknown and vast spectrum of oxynitride thin film compounds.

Project deliverables include:

- A **clean** and **environment-friendly** process (no waste disposal, no hazardous gas emission, no water, soil and air pollution)
- An **extremely versatile** process allowing significant variation of the coating properties
- **Safe** and **inexpensive coatings** (reduction of materials content, materials price and increased lifetime of the products)



Since conventional reactive sputtering with a simultaneous injection of two gases (oxygen and nitrogen) is not a suitable process to deposit metal oxynitride coatings (significant problems of target poisoning), an **original deposition technique** is being developed. Based on the already acquired pre-existing know-how on **Reactive Gas Pulsing Process** (RGPP), this process will be further developed and implemented for the deposition of **TM-O-N coatings** with adjustable and flexible chemical compositions.

The project aims at the long-term innovation exploring potential industrial applications of the new TM-O-N systems in the **decorative surface treatment** sector: watch-making industry, bath and household decorative sector, jewellery. In line with the ever-increasing user demands, the decorative coatings are expected to have several desirable properties such as **specific colour, increased hardness** and **wear-resistance**.

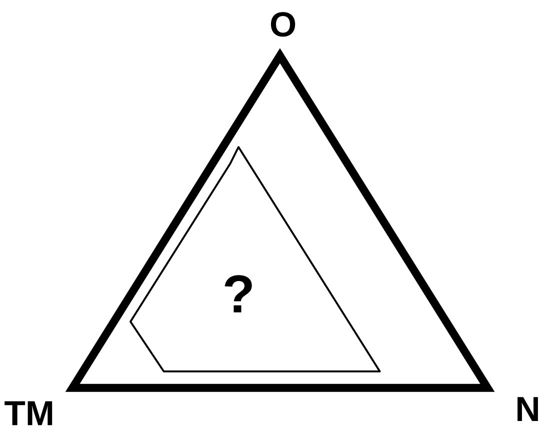
The project success will facilitate the introduction of the coatings in new industrial branches like **micro-, optoelectronics as well as in medical, electrical, automotive, machine parts fabrication and aviation fields**.

Work performed

Six different metals (Fe, Nb, Ta, Ti, Zr and W) were selected among the transition metals series. The choice was motivated assuming their reactivity towards oxygen and nitrogen, but also because of their similar tendency to develop isostructural materials, and thus capable of producing complementary results in order to better understand the materials properties and thus helping in **the transition of laboratory-scale towards the industrial environment**. **Four reactive sputtering processes** are developed to deposit transition metal oxynitride thin films: the conventional reactive sputtering, the pulsed power, the gas mixture and the reactive gas pulsing process. Each process is optimised in order to tune the metalloid concentrations and thus, the behaviours of as-deposited coatings. The use of these different processes is again motivated by the need to answer the different industrial processes available. With this, it is possible, not only to study different (but complementary) systems, but also a wide range of different technological systems available in European coating companies. The reactive gas pulsing process is one of the strongest points in the project, since its use will solve some of the major actual drawbacks in the coatings market: the target poisoning effects, which implies the use of significantly high deposition times and thus money consuming, but also the lost of materials composition uniformity throughout the entire coating thickness and thus properties variation. This is one of the worst and most difficult problems to be solved in industrial terms. The **RGPP** approach is currently developed and studied in the project in order to extend this technique from a laboratory to industrial scale, with the large money and flexibility gains in the materials industrial production. The possibility to prepare extremely different materials (colour, electrical characteristics, and mechanical/tribological response, optical, among others) by changing the ratio of nitride/oxide fractions is in industrial terms a major accomplishment.

Results achieved, intentions for use and impact

The change of the chemical composition of TM-O-N coatings remains one of the most important motivations of the project since the metalloid content (and specially the nitride/oxide ratio) in the films strongly influences their final properties.



Transition metal oxides and nitrides have been extensively studied in the past, whereas little knowledge exists about the oxynitrides. As shown in the ternary diagram TM-O-N above, we focus our study on this poorly explored region to fill the **gap of knowledge** on the relatively new class of materials with combined properties. Up to now, first results clearly revealed that transition metal oxynitride thin films exhibit atypical performances included between metallic and semiconducting behaviours. Such behaviours are strongly related to the amount of oxygen and nitrogen in the coatings. Adjusting some deposition parameters, a wide range of chemical compositions and consequently, **a large panel of properties** can be reached. Synthesis of transition metal oxynitride compounds appears as an original way to produce **multifunctional thin films**. Oxynitride coatings are expected to be competitive with regards to their specific intrinsic colour, optical and electronic properties, and wear and corrosion resistance. As a result, targeted applications should be in decorative, opto-electronic and microtechnology sectors at first. The versatile applicability of these coatings will also open markets in the area of biomedical products, optical components, machining and tooling...

Further expected end results, intentions for use and impact

Combining mechanical performances of nitrides with optical and electrical properties of the oxides, such a synergy should lead to new and original characteristics of transition metal oxynitrides. **Knowledge and understanding** of these **innovative properties** would be achieved by modelling the right structure of oxynitride compounds. Knowledge generated by the project should lead to original and unpublished results regarding the materials science as well as new deposition processes. Focusing the research on transition metal oxynitride thin films deposited by reactive sputtering, the consortium creates an original approach in the field of vacuum coaters. Such oxynitride compounds should widen the coating's multifunctionality since they join the beneficial properties of the metal nitrides with that of the corresponding oxides. At the present time, the potential applications of these oxynitride materials are underestimated. Thus, the long-term innovation HARDECOAT project will pave the way for some unexplored fields of applications.

Consortium

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