coatings

Editorial

Special Issue: Advanced Multielement Coatings, Deposition, Materials, Applications

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Improving the properties of materials used in engineering and in industry is the main axe of materials science. New technology requires high performances, and it is therefore essential to increase functionalities materials. Among different approaches, surface film is one of the important ways, being both promising and cost-effective. Deposition of a layer (from a few nanometers to hundreds of microns) on a surface is now widely used in many industrial fields for many applications. PVD (Physical Vapor Deposition) and CVD (Chemical Vapor Deposition) or thermal spraying are now mature on an industrial scale and are integrated into many manufacturing processes in a wide variety of fields in optics, microelectronics, mechanics, etc.

These technologies can be operated in a controlled atmosphere to produce functional films. The choice of the deposition technique ensuring high quality of functional coatings is then a challenge.

In recent decades, multielement coatings have shown their potential to develop innovative materials. For example, tools used in machining processes are coated with hard films in order to increase their performances (quality of machined surfaces, tool lifetime, etc.). Other coatings have shown their potential against various degradation factors such as wear, corrosion, and oxidation. Providing functional coatings with excellent physico-chemical properties becomes then a high priority in metallurgy field. Advanced multielement coatings are the focus of the innovation in various fields such as aerospace, automotive, cutting tools, nuclear industry, and biomedical.

This special issue aims to provide the last progress on the development of multielement advanced coatings, taking into account design and film architecture. All properties are addressed; optical, electronical, mechanical and tribological performances, high temperature oxidation resistance, corrosion and wear resistances, etc. Providing coatings with superior performances is of key interest for developing many applications.

Metallic and ceramic multielement coatings are under intensive investigation; nitrides and carbides, for instance, are attractive functional materials. Their interest lies in the good physicochemical properties and in the great freedom of material design. However, these developments are accompanied by challenges related to the choice of the composition which is vast. Traditional materials science methodology can be slow to make progress. A new approach is needed then to address the challenges. For this reason, information technology could provide materials science with remarkable tools to make valuable progress.

As an example, multielement coatings having an equimolar composition are materials known as high entropy coatings. They are composed at least of five elements [1,2]. Single-phased solid solution, free of intermetallic phases are reported of the most investigated alloys. The alloys are known under three different terminologies: multi-element alloys, complex component alloys, and Multielement high entropy. Due to their superior properties, high entropy coatings can be exploited to develop materials with high performances and potential applications can be considered. They exhibit excellent mechanical

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and physical properties, for example good wear resistance [3], high corrosion resistance [4], and excellent thermal stability [5].

High entropy coatings can be synthesized by using different approaches such as laser cladding, thermal spraying, magnetron sputtering, etc. Developing high entropy coatings for the aerospace field is particularly important. Investigation of materials containing refractory elements is still at the initial stage. Further developments and investigations are required to understand and to control their physico-chemical properties. Even if refractory high entropy coatings reveal some good performances at elevated temperatures, they are limited for other properties such as ductility at room temperature or oxidation resistance. This point requires more investigations efforts. Several refractory elements, having a high meting point, have been investigated [6]. Multielement coatings are often composed of hafnium (Hf), molybdenum (Mo), tungsten (W), zirconium (Zr), vanadium (V), and niobium (Nb). Their microstructural and mechanical properties as well as oxidation resistance can be optimized by adding other elements, for example aluminum (Al) and silicon (Si).

Concerning this example of high entropy films, the composition choice can strongly influence the properties of multielement materials. The change of the composition can modify the electronic configuration of the material and consequently structure and microstructure can change. The properties of multielement coatings can be then controlled to adapt the materials to a specific application. The addition of titanium and nickel, for example, is expected to improve the room temperature brittleness of the alloys, whereas the addition of aluminum leads to hardening process. Adding Al to some alloys can increase the mechanical properties, hardness, and Young's modulus [7]. Studies of high entropy coatings revealed materials with good wear resistance [8] as well as best corrosion resistance [9].

The coating architecture, which is now often complex, gradually transforms from a single layer to a complex architecture such as multilayers and/or nanocomposites. The objective of multilayers is to obtain high mechanical properties whereas stress level remains relatively low. The design of nanocomposites is also a way to improve the overall performance of the materials.

Applications of multielement materials become a hot spot of many studies. For example, considerable investigations focused on protective coatings to improve the performances of implants and prostheses. Some of multielement coatings have shown a good biocompatibility [10] and others revealed no cytotoxic response has been observed after various hours [11]. The intensive studies of functional multielement coatings cloud revealed materials with superior properties that can be exploited to meet the industry needs.

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