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Editorial

Advances in Surface Modification of the Materials

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The surfaces of engineering materials play key roles in interactions with the environment and very often influence durability under external conditions [1]. In recent years, the development of modern methods of surface modification has become particularly important, as well as in the context of increasing the value of structure materials, especially coatings [2]. The production and formation of protective coatings is carried out using various methods based on deposition by means of PVD [3], CVD [4], friction [5], electric arc, laser beam, electron beam, detonation wave, electrodeposition [6] and other methods. In many cases, surface properties are not an effect of coating deposition but are based on specific treatments by heat or different forms of energy [7].

As the demand for the creation and development of surface properties is still increasing exponentially, experimental and simulation studies are an important factor contributing to their wider conscious use [8].

In this Special Issue, original, scientific, peer-reviewed articles were presented which outline important and recent achievements in the field of surface characterization and modifications with a special emphasis on real or potential applications. Twelve research articles have been published as part of this Special Issue, and all of them are devoted to advanced surface properties.

In [8], four protective coating materials—Inconel 718, Inconel 625, Alloy 33 and Stellite 6—were deposited on 16Mo3 steel tubes by means of CMT (Cold Metal Transfer), as an advanced version of the MAG (Metal Active Gas) welding method. In the next step, the surface of the deposited coating was remelted by means of the TIG (Tungsten Inert Gas) welding method. The SEM microstructures of coatings–substrates have been reported, and the EDX-researched chemical compositions of the coatings were compared to the nominal chemical compositions. The hardness distribution in the cross-section was determined, which revealed that among the investigated coatings, the Stellite 6 layer was the hardest, at about 500 HV0.2. The other materials, i.e., Inconel 625, Inconel 718 and Alloy 33, had cladded zone hardnesses of about 250 HV0.2. The Stellite 6 layer had the lowest wear resistance in the dry sand/rubber wheel test, and it had the highest wear resistance in the erosive blasting test. This reveled the existence of different wear mechanisms in the two test methods used. In the dry sand/rubber wheel test, Alloy 33 and Inconel 718 only had higher wear resistance than substrate 16Mo3 steel. In the abrasive blasting tests, all coatings had higher wear resistance than 16Mo3 steel. However, Stellite 6 coatings had approximately 5 times higher durability than the other investigated (Inconel 625, Inconel 718 and Alloy 33) coatings.

The content of [9] shows nickel-based superalloys as particularly suitable for applications under corrosive conditions. Furthermore, the tribological property profile was significantly improved via surface hardening. In the reported study, the possibility of a process combination comprising a coating and surface-hardening technology was investigated. For this purpose, Inconel 718 coatings were applied to austenitic stainless steel via laser cladding. Subsequently, thermochemical surface hardening via boriding was carried out. The influence of thermochemical hardening was investigated in different wear conditions. The increase in microhardness and wear resistance clearly demonstrated the utilization potential of the presented process combination.

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The aim of [10] was to perform laser-assisted size reduction in nanoparticles of a gold (Au)-sputtered layer on a titanium (Ti) base material using an innovative method that could potentially be applied in novel blood contact and thromboresistive devices in live bodies, such as ventricular assist devices (VADs). The enrichment of the surface layer of titanium with gold nanoparticles, due to their bioproperties, may reduce the number of inflammatory reactions and infections which mainly occur in the first postoperative period and cause implant failure. The evaluation of gold particles was conducted using SEM using SE and QBSD detectors with EDS analysis. Attempts to reduce the deposited gold coating to the size of Au nanoparticles and to melt them into a titanium matrix using a laser beam have been successfully completed. There seems to be no strict relationship between the particle size distribution of gold onto Ti, probably due to the energy being too low to excite titanium enough, resulting from a difference in the Ti and Au melting point temperature. However, the obtained results allow for the continuation of pilot studies for augmented research and material properties analysis in the future.

In [11], the effect of plasma modification on the print quality of biodegradable PLA films was investigated. PLA films, as non-absorbent materials, require modifications to their surfaces before the printing process to improve the wettability of the substrate and to obtain proper ink adhesion to the substrate. In this paper, the surfaces of two kinds of PLA films were modified using plasma activation with parameters enabling high surface free energy (SFE) values, and then, the films were printed on using different kinds of flexographic inks. Two gases, oxygen and argon, were used for activation, as these make it possible to obtain good hydrophilicity and high SFE values while having different effects on the roughness, or the degree of surface etching. Plasma-activated films were subsequently subjected to the measurements of contact angle with water, diiodomethane and three printing inks; the roughness, weight change, strength properties, color, gloss change and SFE were determined. The results showed a strong effect of activation with both oxygen and argon plasma on the SFE value of the films and the contact angles of water and inks, with the gas used for plasma activation and the type of film significantly influencing the thickness of the fused ink layer and the resultant color.

The content of [12] is related to the Atomic Force Microscopy (AFM), method which is widely used in different fields to measure various types of material properties, such as mechanical, electrical, magnetic, or chemical properties. The ratio of dissipation to stored energy is defined as tanδ. This value can provide useful information about the sample under study, such as how viscoelastic or elastic the material is. In this paper, it four different sets of samples were studied, and loss tangent measurements were performed with both the first and second eigenmode frequencies. It was found that performing these measurements with a higher eigenmode is advantageous, minimizing the tip penetration through the surface and therefore minimizing the error in loss tangent measurements due to humidity or artificial dissipations that are not dependent on the actual sample surface.

In [13], the significant problem regarding surface properties was investigated by means of EDEM and the experimental evaluation of the abrasive wear resistance performance of bionic micro-thorn and convex hull geometrically coupled structured surfaces.

The authors of [14] verified the influence of thermochemical treatment on the surface properties of finish turned wire arc sprayed 17Cr steel coatings. In the article, the influence of thermochemical surface hardening on the surface topography of wire arc sprayed 17Cr steel layers after finish turning was investigated. Successful surface hardening via gas nitriding was shown. The surface properties after the various treatment steps were characterized by the surface roughness parameters. An increase in the valley void volume can be beneficial in tribological applications in which a suitable oil retention volume is required. Accordingly, a thermochemical treatment combined with an appropriate subsequent finishing process is suitable to significantly influence the surface properties of thermal spray steel coatings.

The article in [15] was devoted to the quality improvement of laser-induced periodic ripple structures on silicon using a bismuth–indium alloy film. In this work, a new buffer layer material, a bismuth–indium (Bi-In) alloy, was utilized to improve the quality of large-area, laser-induced periodic ripple structures on silicon. The single-spot investigations indicated that ripple structures were much easier to form on silicon coated with the Bi-In film under laser fluences of 2.04 and 2.55 J/cm^2 at a fixed pulse number of 200 in comparison with on bare silicon. The results show that the Bi-In film enabled a wider range of laser fluences to generate periodic structures and helped to form regular ripple structures on the silicon.

The results of research regarding the modification of nanocrystalline porous $Cu_{2-x}Se$ films during argon plasma treatment are presented in [16]. $Cu_{2-x}Se$ films were deposited on Corning glass substrates by radio frequency (RF) magnetron sputtering and annealed at 300 °C for 20 min under N_2 gas ambient. The films had a thickness of 850–870 nm and a chemical composition of $Cu_{1.75}Se$. The initial structure of the films was nanocrystalline with a complex architecture and pores. The investigated films were plasma treated with RF (13.56 MHz) high-density, low-pressure inductively coupled argon plasma. Changes were evident in the surface morphology and chemical composition.

In [17], the analysis of wear resistance based on the Discrete Element Method (DEM), in an abrasive wear system composed of pangolin scale models and abrasive sand was established. Their wear behaviors were discussed regarding the contact bond fields, the contact force chains, the velocity fields and the displacement fields of the abrasive wear system. The results show that the geometrical shape of the pangolin scale is helpful for decreasing the boundary stress, with the wear rate decreasing when the velocity is higher than $0.62\ m \cdot s^{-1}$.

The antifungal properties of pure silver films with nanoparticles induced by the Pulsed-Laser Dewetting process were investigated in [18]. Silver particles were prepared by dewetting Ag films coated on glass using a fiber laser. The structural properties and surface roughness of the particles were evaluated by means of scanning electron microscopy. In addition, the antifungal activity of the Ag particles was examined using spore suspensions of C gloeosporioides. It was shown that particles with sizes of 1.2 µm achieved the 100% inhibition of conidia growth of C gloeosporioides after a contact time of just 5 min.

In [19], the influence of in situ local heat treatment performed via additional stitches on the weldability of high-strength, low-alloy (HSLA) S355J2C+N steel was tested. The local heat treatment was applied as an effect of bead-on plate welding made on the face of a Tekken test joint. The specimens were made using covered electrodes in the water environment. Then, different numbers of pad welds with different overlaps were laid on the face of the tested welds. Microscopic tests proved that the proposed technique affected the structure of the heat-affected zone (HAZ). The specimens in which the additional stitches were applied contained tempered martensite, fine ferrite and fine pearlite in their HAZ. The results of the experiments showed that the heat from pad welds provided microstructural changes in heat-affected zones and a decrease in the susceptibility to cold cracking.

The articles in this Special Issue have been cited more then 40 times so far. This proves the importance of the subjects discussed within them. The Guest Editor would like to thank the authors for submitting original research articles related to the topic of advancements in the surface modification of materials. Moreover, great thanks are given to the reviewers of the articles and the academic editors for their commitment. Special expressions of gratitude are given to Ms. Delia Pan for her invaluable support to the Special Issue editor, and all MDPI staff involved in the publishing process who have contributed to the success of our Special Issue.

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