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Editorial

Ceramic Films and Coatings: Properties and Applications

Qi Zhu

Key Laboratory for Anisotropy and Texture of Materials (Ministry of Education), School of Materials Science and Engineering, Northeastern University, Shenyang 110819, China; zhuq@smm.neu.edu.cn

Ceramic films and coatings play an important role in the field of materials science. As such, various relevant technologies have been developing. The preparation of ceramic films is not a complicated process compared to bulk ceramics. In addition, ceramic films can be manufactured in a variety of shapes to meet both industrial and civil needs. They have recently become a research hotspot, with the aim to develop functional ceramic films and coatings for illumination, anticounterfeiting, anticorrosion, and wear resistance. Nevertheless, high-performance films and coatings are still a challenge to develop due to the fact that the preparation method, ingredients, microstructure, and densification have a significant influence on their properties and applications.

This Special Issue comprises 25 papers, mainly introducing surface coatings, ceramics, luminescence, anti-corrosion, and abrasion resistance. Among them, five papers are on protective coatings, exploring the effects of deposition behavior, additives, and other factors on the corrosion prevention of coatings. A new technique for the high-temperature deposition of low-permeability gas-tight silicon carbide protection coatings is proposed. This coating is effective in preventing the oxidation of SiC-C-Si and SiC-C-$MoSi_2$ ceramics, carbon–carbon composites, structural graphite, refractory metals, and alloys. The test results indicate that the coating has a relatively high thermal oxidation and shock stability, and good adhesion to the substrate [1]. Pyroxene glass–ceramic enamels prepared from blast furnace slag and additives were studied. The batch composition and process regimes of the enamels were elaborated for the production of high-temperature protective coatings for carbon steel. The prepared coatings can be used in corrosive environments and abrasive particles up to 1100 °C [2]. In order to obtain high-performance epoxy coatings for magnesium alloys, polyaniline (PANI) and graphene oxide (GO) composite powders with corrosion inhibition and barrier properties were chosen. In contrast to direct blending, the polymerized powder of polyaniline and graphene oxide can better exert the anti-corrosion and shielding effects of graphene oxide and polyaniline, and provide better protection for magnesium alloys [3]. Si_3N_4/TaC composite MAO coatings were prepared on Ti-6Al-4V (TC4) alloys via microarc oxidation (MAO). The effects of the number of Si_3N_4/TaC particles on the structure, composition, tribological behavior, and corrosion performance of the MAO coatings were studied. The findings show that Si_3N_4/TaC particles can be successfully doped into compound coatings, and the incorporation of Si_3N_4/TaC particles significantly decreases the pores of coatings, which improves the tribological and corrosion performance of complex MAO coatings [4]. WC-Co ceramic materials are widely used as protective coatings in various fields. The deposition behavior of single WC-17Co particles and the microstructure, hardness, toughness, and friction properties of WC-17Co coatings resulting from different spraying methods were studied. The findings indicate that the deposition behavior of single WC-17Co particles on Q235 steel substrate after deposition using varied spraying methods is distinctive [5].

In this Special Issue, five papers explore the impact of coating thickness, additives, and other factors on the wear resistance of coatings. A Si-doped CrN coating was prepared on the surface of W18Cr4V high-speed steel consisting of Si_3N_4 amorphous and CrN nanocrystals. The optimum wear resistance can be achieved by regulating the thickness

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of the coatings. In addition, the influence of toughness on abrasion resistance and the abrasion mechanism was studied [6]. An industrial-scale hot vapor deposition system was used to deposit TiN/Ti(C,N)/Al_2O_3 multilayer coatings. Two Al_2O_3 polycrystalline states were obtained by depositing specific bonding layers at the Al_2O_3/Ti(C,N) interface. The κ- Al_2O_3 multilayer-coated tools had the longest life that was twice as long as that of the CVD Al_2O_3 multilayer-coated ones. These findings can help increase tool properties for the machining of 24CrMoV5-1 steels by expanding the database of existing predictive models for tool wear and machined surface quality [7]. Three composite coatings, Inconel 718 nickel-based high-temperature alloy (IN718), IN718-50 wt.% WC prepared by adding WC particles, and IN718-50 wt.% WC prepared with the assistance of ultrasonic vibration, were prepared via laser cladding. The incorporation of WC increased the hardness and enhanced the tribological properties. Ultrasonic vibration significantly improved the solidification organization and reduced the aggregation of reinforcing particles [8]. TiN coatings were deposited on the surface of AISI 304 stainless steel via DC magnetron sputtering at four various nitrogen flux ratios to modify the structural features of the coatings. Furthermore, the structural characteristics of TiN coatings on AISI 304 stainless steel were modulated to improve mechanical and tribological performance [9]. Solid lubricated composite TiN coatings containing Pb additives were prepared on steel and titanium substrates using a split cathode-reactive magnetron sputtering process. The nanocomposite coatings have a high Pb content, good microhardness, low grain size, and excellent tribological properties [10].

This Special Issue includes two papers on phosphor particles, discussing the effects of the reaction conditions, dopant concentration, and other factors on the optical properties of phosphors. The $ZnGa_{2-x}(Mg/Si)_xO_4{:}Cr^{3+}$ nanoparticles were synthesized employing the sol-gel method. The sample emitted near-infrared radiation at 694 nm in the dominant band, which lasted more than 48 h after UV irradiation cessation [11]. The $RE_4O(OH)_9NO_3$ (RE = Y, Eu) crystalline microcrystals were successfully obtained using the hydrothermal method, and the surface modification of the microcrystalline surface was carried out via a reaction with vanadate ions. The red emission intensity of the microcrystals at 617 nm significantly improved due to the energy transfer of $VO^{3-}\rightarrow Eu^{3+}$ and the light harvesting ability of VO^{3-} [12]. In addition, three papers on luminescent films and coatings are included in this Special Issue. The YVO_4 thin films were hydrothermally prepared in 1 h at ~8 pH using layered yttrium hydroxide ($Y_2(OH)_5NO_3{\cdot}nH_2O$) films as sacrificial precursors. The Eu^{3+}- and Dy^{3+}-doped YVO_4 films showed red and green emission, respectively [13]. The $GdAlO_3{:}Eu^{3+}$ transparent ceramic films were prepared by a two-dimensional interfacial reaction using rare-earth-derived layered gadolinium hydroxide exfoliated nanosheets. They have a high transmittance of more than 90% in the visible range and exhibit strong red emission under the UV excitation of 254 nm [14]. Moreover, a long-persistent luminescent coating using $SrAl_2O_4{:}Eu^{2+},Dy^{3+}$ phosphor was developed for luminescent road markings, offering safety and energy saving benefits. The addition of SiO_2 and $CaCO_3$ improved the dispersion and densification of the luminescent coating. The afterglow of the luminescent coating can be more than 5 hours after sunlight excitation [15].

Three papers in this Special Issue are concerned with transparent ceramics. The Yb:YAG transparent ceramics were prepared using the solid-state method and vacuum sintering technique. After a series of characterization and analysis, it was concluded that the properties of Yb:YAG ceramics were not related to the content of Yb [16]. A simple method for the preparation of ZrO_2-coated Y_2O_3 nano-powder from zirconium nitrate and industrial Y_2O_3 solutions is presented. The transformation process of the ZrO_2-coated layer during calcination was investigated, and the sample obtained showed a transmittance of 81.4% at 1100 nm [17]. Improving the phase domain uniformity and reducing the phase domain size are effective ways to increase the transmittance and mechanical hardness of nanocomposites. The Gd_2O_3-MgO nano-powders produced via the urea precipitation method have good transmittance and high Vickers hardness in the mid-infrared band of 3–6 μm, mainly attributed to the uniform distribution of phase domains [18]. Moreover, the Special Issue includes two papers discussing microwave absorbing materials. $CoFe_2O_4$/SWCNTs composites with a necklace-like structure were produced using a simple solvent–thermal method, which is conducive to good impedance matching and results in excellent electromagnetic loss performance [19]. MnO-Co@C nanorods with a core shell structure were produced via in situ polymerization and high-temperature carbonization processes. The special composite structure formed resulted in better impedance matching and improved microwave absorption ability [20].

This Special Issue also includes three papers exploring the mechanical properties of materials by manipulating the content of additives. By controlling the addition quantity of $TiC_{0.7}N_{0.3}$ and hot-pressing sintering temperature, the influence on the microstructure, mechanical properties, particle size distribution, and relative density of Si_3N_4 ceramic cutting tools was explored, and finally the micro-nano Si_3N_4-based ceramic cutting tool materials with excellent toughness were successfully obtained [21]. WC-13Co composites with added Fe were produced via the pressureless sintering method, and the effects of Fe and C addition on the structural and mechanical performance in the W-Co-Fe-C system were investigated. With the addition of appropriate Fe and C, the hardness of the samples was improved, with an increase in fracture toughness [22]. WC-13Co cemented carbide was produced using the pressureless sintering method; the effects of the Mo and C content on its structure and properties were investigated, and the evolution mechanism of the eta phase during the sintering process was introduced in detail [23]. Finally, there two papers outline anti-corrosion coatings, including conductive and corrosion-resistant phosphate conversion coatings on an AZ91D magnesium alloy [24], and a self-healing microcapsule coating based on epoxy resin [25].

This Special Issue highlights the outstanding achievements in this field, which will help promote the future development of ceramic film and coating technology.

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