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EDITORIAL

SPECIAL SECTION

Modern materials – obtaining and characterization (alloys, polymers)

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1. INTRODUCTION

The development of the world economy is closely related to modern materials, the properties of which are constantly being improved. The reason is that the products obtained must fulfil strict requirements and meet several standards. Constant changes in the production processes of these materials may facilitate regulating their properties during the production process itself. In addition, these properties can be improved as a result of properly performed refinement.

The most commonly used materials today are various types of alloys, polymers, and composites. Particularly interesting groups of modern materials are geopolymers [1, 2] or bulk amorphous alloys [3–5].

The submitted collection of articles presents a summary of the latest knowledge in the field of advanced materials. The review covers papers related to the engineering of metal materials, both steel and non-ferrous metals, as well as thin ceramic layers and nanomaterials.

2. MODERN MATERIALS – OBTAINING AND CHARACTERIZATION

The currently observed rapid technological development, especially in the field of electronics, telecommunications, and automotive industry, requires a continuous improvement of solutions based on the use of modern materials with improved properties. For this reason, ever-increasing demands for improvement have resulted in the development of both advanced materials and their production methods. Therefore, due to the importance of the development of advanced functional materials and nanomaterials, the newest Special Section in "BULLETIN OF THE POLISH ACADEMY OF SCIENCES" is focused on recent trends in customizing and improving their properties, i.e., plastic deformation, mechanical alloying, and applying coatings using CVD, PVD and ALD methods. In addition, the study contains chapters describing the manufacturing and properties of innovative coatings and nanostructures.

This issue also includes a scientific study on modern rapidly cooled materials with ferromagnetic properties. An interesting and constantly researched material with a septal application is titanium and its alloys, on which an extensive study has been published.

In the presented study, one can distinguish a part covering works in the field of shaping the structure and properties of composites and metal materials (especially steel):

- Particle-reinforced PM 8009Al matrix composites [6]
- PFA polymer/compressed expanded graphite – matrix composites [7]
- Silicon nitride/ carbon nanotube composites [8]
- Mechanisms of plastic deformation light high-manganese steels of TRIPLEX type [9]
- Analysis of the precipitation process of secondary phases after long-term aging of the S304H steel [10]
- Obtaining alloys by the suction method [11]

as well as non-ferrous materials

- Synthesis of Mg-based alloys with a rare-earth element addition by mechanical alloying [12]

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- Mechanical alloying of Mg-Zn-Ca-Er alloy [13]
- Analysis of the structure and properties of titanium alloys [14]

Out of all engineering materials, metallic materials are still the most popular due to their favorable mechanical, physical, chemical properties and the possibility of their improvement in many different processing techniques (i.e., mechanical, chemical, thermal, thermomechanical, laser treatment).

The articles present in detail the methods of modifying the chemical composition through precipitation processes as well as the effect of hot plastic deformation conditions with different cooling variants on the structure of various types of steel or magnetic materials or titanium alloys. The paper highlights the importance of the process of designing new steels and alloys for operation at elevated and high temperatures and magnetic materials and titanium alloys.

The growing interest in magnesium alloys in important sectors of the industry that results from their high specific strength, machinability, and recyclability is noteworthy. Hence, the list includes an article focused on magnesium alloys with a particular emphasis on Mg-based alloys with a rare-earth element addition prepared by mechanical alloying (MA). Such treatment led to the achievement of precisely tailored properties, matched for specific applications by synthesis and control of the material structure, which perfectly fits the definition of advanced materials engineering.

The study also includes papers on thin ceramic films and nanostructures:

- Investigations of TiO_2, Ti/TiO_2, and $Ti/TiO_2/Ti/TiO_2$ coatings produced by ALD and PVD methods on Mg-(Li)-Al-RE alloys substrates [15].
- The high-temperature resistance of silicide coated niobium [16].
- Characterization of morphology and optical properties of SnO_2 nanowires prepared by electrospinning [17].

Nowadays, coatings in the form of thin films are becoming more and more popular due to their mechanical, tribological, anti-corrosive as well as electrical, optical, and thermal properties.

The study in the paper describes the layers of the Ti/TiO_2 and $Ti/TiO_2/Ti/TiO_2$ deposited by the atomic layer deposition ALD and MS-PVD magnetron sputtering technique. The result of the conducted research proved the high electrochemical properties exhibited by TiO_2 layers.

Moreover, the oxidation resistance of the niobium silicide coatings deposited with the use of the CVD technique on the surfaces of pure niobium was presented.

It should be noted that the study contains a description of the latest achievements in the field of advanced materials engineering, i.e., technology of 1D nanomaterials in the form of SnO_2 nanowires. One-dimensional nanomaterials are characterized by favorable optical and electrical properties, combined with good thermal and chemical stability, which makes them extremely promising from the point of view of the application in modern electronics, including optoelectronics and photovoltaics.

Rapid-cooled magnetic materials are other very interesting materials that can be used in electronics or electrical engineering. These types of materials are in constant demand due to their unique properties [11]. The change of structure in specially designed materials as a result of rapid cooling generates completely new, unprecedented properties of these materials.

Materials that can be used to directly save human health and life deserve special attention. In particular, these are titanium-based materials. Due to the excellent biological properties in relation to the human body, this type of material deserves special attention. In numerous scientific and industrial centers, intensive research is carried out on new titanium alloys with increasingly improving properties while maintaining their highest possible biocompatibility to the human body [14].

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REFERENCES

[1] S. Luhar, T.W. Cheng, D. Nicolaides, I. Luhar, D. Panias, and K. Sakkas, "Valorisation of glass wastes for the development of geopolymer composites—Durability, thermal and microstructural properties: A review," *Constr. Build. Mater.*, vol. 222, pp. 673–687, 2019.

[2] K. Zulkifly *et al.*, "Elevated-Temperature Performance, Combustibility and Fire Propagation Index of Fly Ash-Metakaolin Blend Ge-opolymers with Addition of Monoaluminium Phosphate (MAP) and Aluminum Dihydrogen Triphosphate (ATP)," *Materials,* vol. 14, p. 1973, 2020.

[3] S. Hasani, P. Rezaei-Shahreza, A. Seifoddini, and M. Hakimi, "Enhanced glass forming ability, mechanical, and magnetic properties of $Fe_{41}Co_7Cr_{15}Mo_{14}Y_2C_{15}B_6$ bulk metallic glass with minor addition of Cu," *J. Non-Cryst. Solids*, vol. 497, pp. 40–47, 2018.

[4] J. Zhou, W. Yang, C. Yuan, B. Sun, and B. Shen, "Ductile FeNi-based bulk metallic glasses with high strength and excellent soft magnetic properties," *J. Alloys Compd.*, vol. 742, pp. 318–324, 2018.

[5] M. Nabiałek *et al.*, "Relationship between the shape of X-ray diffraction patterns and magnetic properties of bulk amorphous alloys $Fe_{65}Nb_5Y_{5+x}Hf_{5-x}B_{20}$ (where: 0, 1, 2, 3, 4, 5)," *J. Alloys Compd.,* vol. 820, p. 153420, 2020.

[6] S. Chen *et al.*, "Elevated-temperature tensile deformation and fracture behavior of particle-reinforced PM 8009Al matrix composite," *Bull. Pol. Acad. Sci. Tech. Sci.*, vol. 69, no. 5, p. e138846, 2021, doi: 10.24425/bpasts.2021.138846.

[7] S. Berdowska, J. Berdowski, and F. Aubry, "The relationship between the structural anisotropy of the PFA polymer/compressed expanded graphite-matrix composites and acoustic emission characteristics," *Bull. Pol. Acad. Sci. Tech. Sci.*, vol. 69, no. 5, p. e138235, 2021, doi: 10.24425/bpasts.2021.138235.

[8] M. Mikuśkiewicz, "Silicon nitride/carbon nanotube composites: preparation and characterization," *Bull. Pol. Acad. Sci. Tech. Sci*., vol. 69, no. 5, p. e138234, 2021, doi: 10.24425/bpasts.2021.138234.

[9] L. Sozańska-Jędrasik, W. Borek, and J. Mazurkiewicz, "Mechanisms of plastic deformation in light high-manganese steel of TRIPLEX type," *Bull. Pol. Acad. Sci. Tech. Sci*., vol. 69, no. 5, p. e137412, 2021, doi: 10.24425/bpasts.2021.137412.

[10] A. Zieliński, R. Wersta, and M. Sroka, "Analysis of the precipitation process of secondary phases after long-term ageing of S304H steel," *Bull. Pol. Acad. Sci. Tech. Sci*., vol. 69, no. 5, p. e137520, 2021, doi: 10.24425/bpasts.2021.137520.

[11] K. Pawlik, "Structure and properties of suction-cast Pr-(Fe, Co)-(Zr, Nb)-B rod magnets," *Bull. Pol. Acad. Sci. Tech. Sci.,* vol. 69, no. 5, p. e138971, 2021, doi: 10.24425/bpasts.2021.138971.

[12] S. Lesz, B. Hrapkowicz, K. Gołombek, M. Karolus, and P. Janiak, "Synthesis of Mg-based alloys with rare-earth element addition by means of mechanical alloying," *Bull. Pol. Acad. Sci. Tech. Sci*., vol. 69, no. 5, p. e137586, 2021, doi: 10.24425/bpasts.2021.137586.

[13] B. Hrapkowicz, S. Lesz, M. Kremzer, M. Karolus, and W. Pakieła, "Mechanical alloying of Mg-Zn-Ca-Er alloy," *Bull. Pol. Acad. Sci. Tech. Sci.*, vol. 69, no. 5, p. e137587, 2021, doi: 10.24425/bpasts.2021.137587.

[14] A.M. Țițu, A.B. Pop, M. Nabiałek, C.C. Dragomir, and A.V. Sandu, "Experimental modeling of the milling process of aluminum alloys used in the aerospace industry," *Bull. Pol. Acad. Sci. Tech. Sci*., vol. 69, no. 5, p. e138565, 2021, doi: 10.24425/bpasts.2021.138565.

[15] M. Staszuk *et al*., "Investigations of TiO_2, Ti/TiO_2, and $Ti/TiO_2/Ti/TiO_2$ coatings produced by ALD and PVD methods on Mg-(Li)-Al-RE alloy substrates," *Bull. Pol. Acad. Sci. Tech. Sci*., vol. 69, no. 5, p. e137549, 2021, doi: 10.24425/bpasts.2021.137549.

[16] R. Szklarek *et al*., "High temperature resistance of silicide-coated niobium," *Bull. Pol. Acad. Sci. Tech. Sci*., vol. 69, no. 5, p. e137416, 2021, doi: 10.24425/bpasts.2021.137416.

[17] T. Tański, W. Smok, and W. Matysiak, "Characterization of morphology and optical properties of SnO_2 nanowires prepared by electrospinning," *Bull. Pol. Acad. Sci. Tech. Sci*., vol. 69, no. 5, p. e 137507, 2021, doi: 10.24425/bpasts.2021.137507.

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