Gordana Bogdanović[1)]
Dragan Čukanović[2)]
Aleksandar Radaković[3)]
Ljiljana Veljović[1)]

1) Faculty of Engineering, University of Kragujevac, Serbia gocab@kg.ac.rs, veljovicljilja@yahoo.co.uk
2) Faculty of Technical Sciences, University of Priština, Kosovska Mitrovica, Serbia dragan.cukanovic@pr.ac.rs
3) State University of Novi Pazar, Serbia aradakovic@np.ac.rs

IMPACT OF MODERN MATERIALS DEVELOPMENT ON QUALITY OF LIFE

Abstract: *In this paper, the effect of continuous industrial development which causes need to replace conventional materials with new, modern materials, and thus improve quality of people's lives, is considered. Hierarchical development of modern materials with the accent on composite materials is presented. Special emphasis is placed on the functional graded materials as advanced materials in the family of engineering composite materials which is made of two or more constituents with continuous and discontinuous variation of chemical composition through a defined geometric distance. Development of functionally gradient material is given. Some of the modern methods of processing functionally gradient materials in order to achieve a gradient of material characteristic in the desired direction are mentioned. The advantages and disadvantages of modern functional gradient materials compared to conventional materials are described. The importance of new materials for modern industry is described through the examples of applications in the aerospace industry, automotive industry, mechanical engineering, civil engineering, etc. Based on the presented advantages and disadvantages of modern materials appropriate conclusions are given.*

Keywords: *modern materials, functionally graded materials, quality of life*

1. INTRODUCTION

Materials have a very important role in the development of our culture and society [1]. In the modern society, materials are emerging as one of the most significant areas of research on a global level and through various disciplines. Regardless of whether they are a natural resource or a product of artificial substances, all the materials people use have an enormous impact on the environment, economy, health, and finally, on the quality of life of people as end users. People have always strived to improve their lifestyle. Continuous development of industry imposed the need for replacing conventional materials with new and modern ones wherever possible, making the environment we live in a more secure and better place. One of the most illustrative examples of the importance of modern materials usage for the life quality is the fact that people, nowadays, have better healthcare, longer life and thus a better quality of life due to innovative materials. Moreover, the use of modern materials in automobile industry or civil engineering makes our environment and surroundings safer and more comfortable and secure. The use of available materials in different organic and inorganic compounds opened up the path towards the development of advanced polymers, engineering alloys,

structural ceramics and set the aim of producing new, modern materials which would have better characteristics from already existing, conventional meterials. Hierarchical development of modern materials is presented in Figure 1.

2. FUNCTIONALLY GRADED MATERIAL

Functionally graded materials (FGM) are modern materials in the family of engineering composite materials. Functionally graded materials are multi-layer materials in which there is a continuous and a discontinuous variation of their chemical composition and/or microstructure (grain size, thickness/porosity) through a defined geometric distance. Gradients can be continuous and discontinuous on a microscopic level. There are different techniques for processing FGM and controlling both its composition and structure. Continuous improvement of processing methods enabled new systems to be created and many engineering problems to be solved using the concept of gradient materials. After many decades of research and development, FGM represent a class of attractive materials that can form a gradient property, which is impossible to achieve with any other spatially homogeneous material.

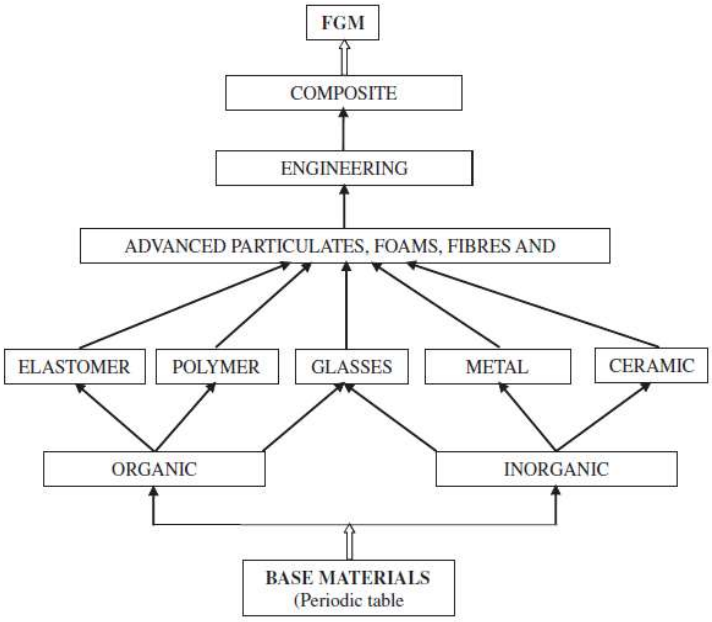

Figure 1. *Modern material hierarchy*

Today, it is possible to create FGM with the gradient of electrical and/or thermal properties and with exceptional mechanical and technical characteristics [2]. Mechanical properties, such as: elastic modulus, Poisson's ratio, shear modulus, as well as material thickness, vary continuously in recommended directions. These materials are constantly getting a wider usage in various different branches of engineering and technology with a aim to use their properties in the best possible way by appropriately combining the potentials of the available materials. That includes reduction of plane stresses and transverse stresses through plate thickness and improvement of thermal properties, toughness etc. Breaking and delamination

between layers is the biggest and the most frequently studied problem concerning conventional composite laminates. Delamination of layers due to high local inter-laminar stresses causes a reduction of stiffness and a loss of structural integrity of a construction which finally results in functional failure of the construction. In order to eliminate these problems, FGM are used [3], which are becoming very important as advanced materials for innovative engineering constructions (Figure 2).

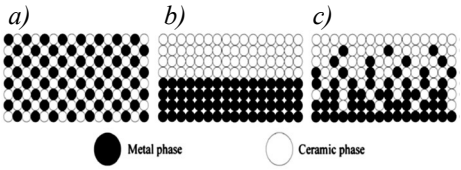

Figure 2. *homogeny composite (a), laminate composite (b) and functionally graded composite (c)*

3. HISTORY OF FGM

Although, at first glance, it seems that the concept of FGM occurred as the result of engineering invention, the idea of making this kind of materials actually comes from nature itself. This kind of materials exists in nature in a form of human skin, bones, trees, bamboo etc. So, for example, human skin has a gradient structure in a thickness direction with the aim of providing appropriate toughness, sensitivity and elasticity depending on the location on the body or skin depth. Based on this concept, FGM appeared, containing most often two, although they can contain more isotropic material phases. These components often include engineering magnesium, aluminium, copper, titanium, tungsten, and iron alloys and advanced structural ceramics such as zirconia, alumina, silicon carbide and tungsten carbide. FGM are first mentioned in the Japanese government program within which there was a program for development of structural materials which could respond to the needs and requests of new and modern technology. New technologies require new and modern materials with multiple functions which already existing conventional materials do not possess. Following the "First International Symposium on Functionally Gradient material" held in Japan, these materials started their fast development.

4. PROCESSING TECHNIQUES FOR FGM

Functionally graded materials can be formed using powders, melts as well as polymers [4], [5]. A number of different methods for FGM production have been developed, which enable both the content and structure control. The most frequently used methods for FGM production are: powder processing, thermal dispersion, diffusion processes, sedimentation, self-propagating high-temperature synthesis, reactive infiltration and many more. Physical and chemical vapor depositions are techniques used mainly for processing of FGM films with gradient content at the nanometer level.

5. APPLICATIONS OF FGM

FGM have a great potential and they can be used for medical purposes, in energy sector, space projects, nuclear projects, automobile industry, civil engineering etc. (Figure3).

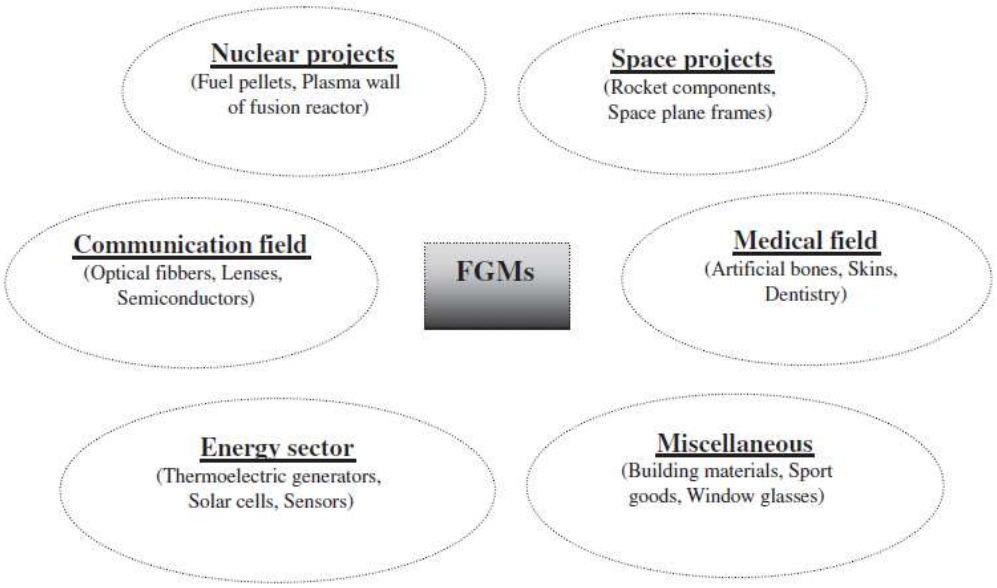

Figure 3. Fields for the application of FGMs

What differentiates these materials from conventional ones is the fact that it is convenient to use them in very difficult operating conditions such as for heat shields of spacecrafts, heat exchangers, biomedical implants, plasma-sprayed coatings for fusion reactors etc. FGM can also be used in information and communications technology. It can be concluded that FGM, not only eliminate disadvantages of conventional materials and laminate composites, but such materials also have unique positive properties. The use of composite materials in industrial production is getting bigger every day. Figure 4 shows a market share of different composite materials in different branches of industrial use [6].

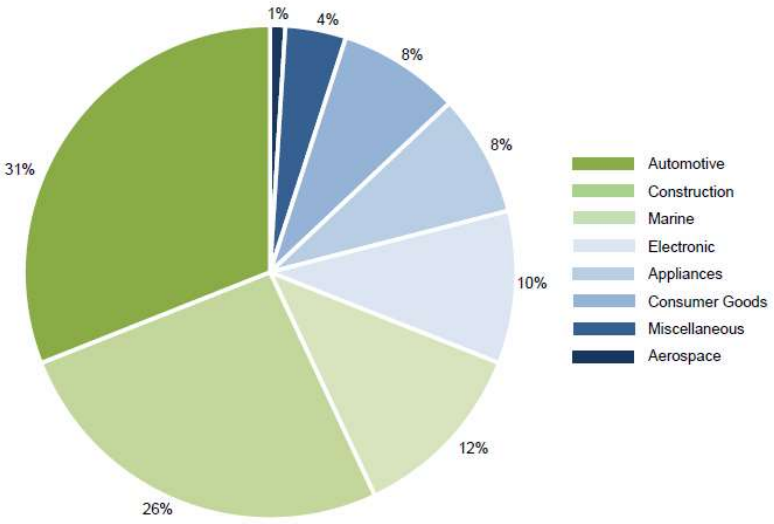

Figure 4. Market share of different composite materials

6. CONCLUSION

Modern materials, as one of the most important area of research, will have a fundamental importance for the revolution in manufacturing and engineering in the 21st century. FGM, as modern materials in a family of composite materials, are very important for engineering, but considerable expenses of their production still make them unprofitable in some applications. Further development of these materials will make their fabrication cheaper with the aim of achieving a better market price and creating possibilities for even broader usage. Moreover, the tendency of people on one side and the inevitable industrialization on the other side is directed towards innovation and using new and modern materials in a way which positively affects our environment, economy, health and, finally, life quality of people as end users of the product.

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