CERAMIC COMPOSITES BASED ON FUNCTIONALIZED GRAPHENE OXIDE AND ALUMINA

G.G. Bokuchava[1,a], E.E. Sanaia[1,b], T.N. Archuadze[1,c], T.V. Kuchukhizde[1,d], N.T Jalagonia[1,e]

[1]*Ilia Vekua Sukhumi Institute of Physics and Technologies, Tbilisi, Georgia*
[a]sipt@sipt.org.ge, [b]esaniaa@gmail.com , [c]tamari.tamriko@gmail.com , [d]tinikokuchukhidze@gmail.com,
[e]n.jalagonia@sipt.org.ge

Abstract. Improvement of the physical-mechanical properties of ceramics to a certain degree became possible by reducing the size of particles of sintered powders to nano sizes, also by doping different type structure containing compounds (Nanofibers, nanotubes, nanonets and other) and selection of consolidation optimal regimes. Homogenization of nanomaterials into ceramic composites have significantly influence on its' mechanical properties. For purpose, we have carried out functionalization of graphene oxide by organic compound and homogenization in alumina has conducted by grinding in nanomill during 24 h. Following ceramic composites have obtained by hot pressing method: α-Al_2O_3, α-Al_2O_3-GO, α-Al_2O_3- ZrO_2-Y_2O_3-GO, α-Al_2O_3- ZrO_2-Y_2O_3-GO_{mod}. Structure, morphology and mechanical properties of obtained materials have investigated. It is established, that mechanical characterization is improving by addition various nanoparticles into alumina.

1. Introduction

Recently obtaining of ceramic materials have a big attention, because they are characterized high physical-mechanical properties, corrosion ressitance, eqspluatation possibility at high temperature (1400-2000^{O}C) and other. Powdery technology are used often for fabrication a new materials, which implies elaboration of obtaining method of various type and purposes powdery and further fabrication of ceramic materials with high exploitation properties. Nowadays, main focus is to nanotechnologies for obtaining nanopowders and its' based on nanostructural materials. Materials physical-mechanical properties are depend on consolidation process of powdery. Several methods are using for consolidation of powdery, such as gradually increasing of consolidation temperature, consolidation method using microwave oven, spark-plasma sintering, consolidation in induction furnace and other [1-3].

It is known in literature, that graphene is most stsrength material, that's why increases physical-mechanical properties of materials addition of its' in ceramic [4-5]. We have used hot pressing method for obtaining of ceramics. Preparation of graphene monolayer is actual problem, which is related to cost, time and other, because of this graphene oxide are used mostly. For purpose, Obtaining of hard ceramic materials, graphene oxide was functionalized by organic compounds (polyvinyl alcohol (PVA), polyethylene glycol (PEG). Then functionalized graphene oxide was added in alumina and homogenization process carried out in nanomill during 24 h. Organic compounds are allocated form graphene oxide at high temperature during sintering, so being reduction of graphene oxide. This kind reduced graphene oxide has mostly similar properties as graphene, which have influence on physical-mechanical properties of ceramics.

2. Experimental procedure and sample preparation

Synthesis of graphene oxide. Synthesis of graphene oxide have conducted by intercalation method from graphite. Graphite flakes (2 g) mixed in 50 mL of H_2SO_4 (98%) and potassium permanganate (6 g) very slowly during 1 h. The flask kept under at ice bath (27-35°C) with continuous stirring. After 1 h 100 ml water was added in the mixture. Then continue stirring again about 1 h and 20 mL H_2O_2 was added. After washing and filtration, the mixture centrifugation has done. Stable graphene oxide suspensions have obtained which used as reinforcement materials in ceramic composite.

Functionalization of graphene oxide. 1 g graphene oxide was dispersed in 100 mL H_2O using ultrasound bath. Obtained stable suspension and added 1 g PVA (or PEG), mixture was treated by ultrasound bath again. Identification of materials have been done by modern research methods.

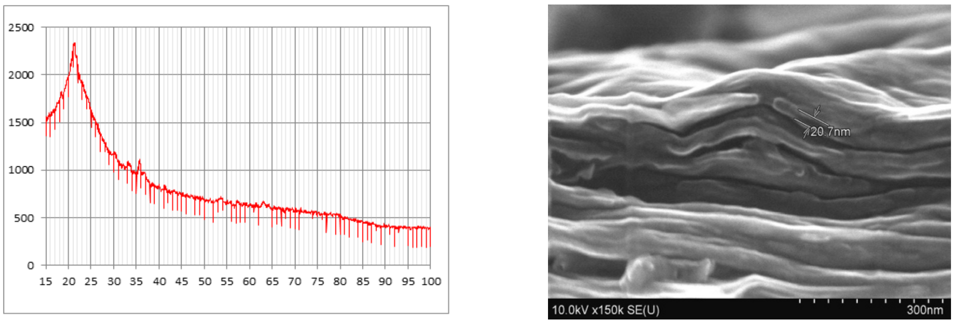
Preparation of pressing powdery composite. 65 g α-Al_2O_3 was mixed to functionalized graphene oxide (1.5% mas.). 100 mL H_2O was added into mixture and homogenization carried out by nanomill during 24 h. Then the mixture dried and placed in press form.

Sintering was performed using nanopowders hot pressing installation with direct current passage under a pressure 40MPa and holding for 2min at various temperatures. Further studies were performed on samples molded - tablets with a diameter of 20 mm and a height of 4 mm.

The phase composition of the samples was determined by X-ray diffraction X-ray diffractometer DRON-3M.

3. Results of hot vacuum pressing of nanopowders

Obtained graphene oxide was investigated by SEM, identification was carried out by Raman, FTIR and UV, particles sizes was measured by laser nanosizer.



(a) (b)

Fig. 1Elecrtonic micrograph (a) and XRD (b) of graphene oxide

As electronic micrographs showed, average number of reduced graphene oxide layers are 20-40 nm and graphene oxide particles sizes are approximate 50-90 nm in suspension.

Various type ceramic composites have obtained by high temperature vacuum furnace (OXY-GON), such as: α-Al_2O_3-GO, α-Al_2O_3-ZrO_2-Y_2O_3-GO, α-Al_2O_3-ZrO_2-Y_2O_3-GO_{mod}. Graphene oxide was synthesized with particle sizes ~50-96 nm by proved method in the literature. Then graphene oxide modification was conducted by organic compounds (PVA, PEG).

Ceramic composites dopped functionalized graphene oxide was sintered in high temperature furnace with 50 mm dimeter sizes. Physical-mechanical and structural-morphological research has been conducted for obtained materials.

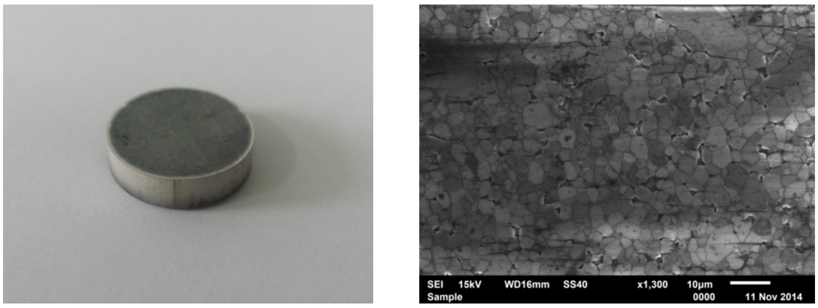


Fig. 2 Electronic micrograph and ceramic material

Corundum ceramic materials have obtained at 1600°C (1h), which characterized with high hardness, crack and corrosion resistance. Their density reaches to 99,5-99,6% of theoretical.

Conclusions

In this work, reduced graphene oxide preparation method was developed. Matrix composites have obtained based on graphene structure and alumina. Following ceramics α-Al_2O_3-GO, α-Al_2O_3-ZrO_2-Y_2O_3-GO, α-Al_2O_3-ZrO_2-Y_2O_3-GOmod have fabricated at 1600^{O}C by high temperature vacuum furnace. Physical-mechanical properties, phase composition and microstructure of matrix ceramic materials have been established.

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