CERANEA: Multifunctional Ceramic/Graphene Coatings for New Emerging Applications

Main area: BSR04_Functional ceramics incorporating GRMs
Keywords: non-oxide ceramics, graphen, 2D materials, electrical, thermal properties, coatings
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Abstract

The goal of the project is to develop novel functionally graded materials (FGM) which are containing sandwich structures with several functional layers. These advanced layer stacks will contain graphene, BN and other 2D materials as well as ceramic layers based on known materials, optimized for dedicated combinations of electrical, thermal and mechanical properties. These multilayer coatings - in combination with substrates or skeletons – will form novel types of nanocomposites. The process for manufacturing these ceramic composites will be spark plasma sintering and hot isostatic pressing (SPS/HIP). The proper design of the distribution/stacking of graphene in combination of other ceramic layers, and the tailoring the ceramic and graphene interfaces allow an efficient transfer of electrical, thermal and mechanical loads in widely used non-oxide engineering ceramics. Transport properties of graphene additive with a two-dimensional (2D) hexagonal honeycomb lattice could be reflected in their electrical conductivity and thermal conductivity. The aim of work is development of ceramic/graphene multifunctional coatings by powder technology as electrical and thermal conductive layers for new emerging applications. The understanding of synthesis-structure-properties relationship will be optimized with the goal to tailor the electrical and thermal properties of non-oxide ceramic/graphene composite while maintaining the excellent mechanical properties.The research activities in German group and Xinliang Feng's group are linked by common research activities in the Center of Excellence “Advancing Electronics Dresden” at Technical University Dresden, e.g., synthesis of 2D crystalline polymers and carbon-based nanostructures, photo-electrochemical water splitting etc. The research activities in Hungarian group are focused to new cost effective high quality carbon based filamentous materials developed in the form of graphene platelets (GPLs), also called graphene nanoplatelets (GNP), multilayer graphene nanosheets (MGN). This large scalable, very cost-efficient and fast method promised a homogenous distribution of the graphene in the ceramic matrix and can be easily up scaled. The research activities in Slovakian group are linked to ceramic/graphene composites by innovative SPS or HP technologies as electrical and thermal conductive layers for emerging applications. Technical goals:•Development of non-oxide ceramic (Si3N4, SiC)/graphene multilayer coatings and large scale graphene powder synthesis that is suitable as additives to ceramics•Design of the one step sintering processes of functionally graded composites (FGM) containing sandwich structures with several functional layers. Examples of the focused layered structures are:-top layer with high (5-30 wt. %) graphene content in ceramic that is characterized by electrical conductive skeleton structure with high porosity, machinability by electrical discharge machining, self-monitoring ability, improved thermal conductivity in plane); second layer with lower graphene content in ceramic showing lower electrical conductivity and dense structure; third layer ceramic-top layer with high (5-30 wt. %) BN and graphene content ceramic that is skeleton-like as it is with higher porosity, aimed to be used as contacts at higher temperatures where BN will act as a protection of graphene layer; second layer with lower content of BN and graphene in ceramic; third layer ceramicThe consortium aim is the development of multi-layered sandwich structure as a new concept to obtain the multifunctionalities in the synthesized non-oxide ceramic/graphene nanocomposites. This research will be focused to fundamental understanding of synthesis, compacting and coating processes governed by mechanical deformation and percolation of additive phases, and characterization of multifunctional conductive non-oxide ceramic/graphene coatings for future potential solutions to automotive and aerospace industry.

Consortium

Csaba Balazsi – Hungarian Academy of Sciences, Centre for Energy Research – Hungary – Funded by: NKFIH (Coordinator)

Ehrenfried Zschech – Fraunhofer Institute for Ceramic Technologies and Systems – Germany – Funded by: DFG

Jan Dusza – Institute of Materials Research – Slovakia – Funded by: SAS