



# FLAG-ERA

## Multifunctional Ceramic/Graphene Thick Coatings for New Emerging Applications

### „CERANEA”

**Coordinator:** Centre for Energy Research (MTA EK), Budapest, Hungary

**Partners:** Fraunhofer IKTS, Dresden, Germany

Institute for Materials Research (IMR SAS), Kosice, Slovakia

Project duration: 2018. April 1<sup>th</sup> – 2021. March 31<sup>th</sup>

**Coordinator: Prof. Csaba Balázs,**

Scientific Advisor

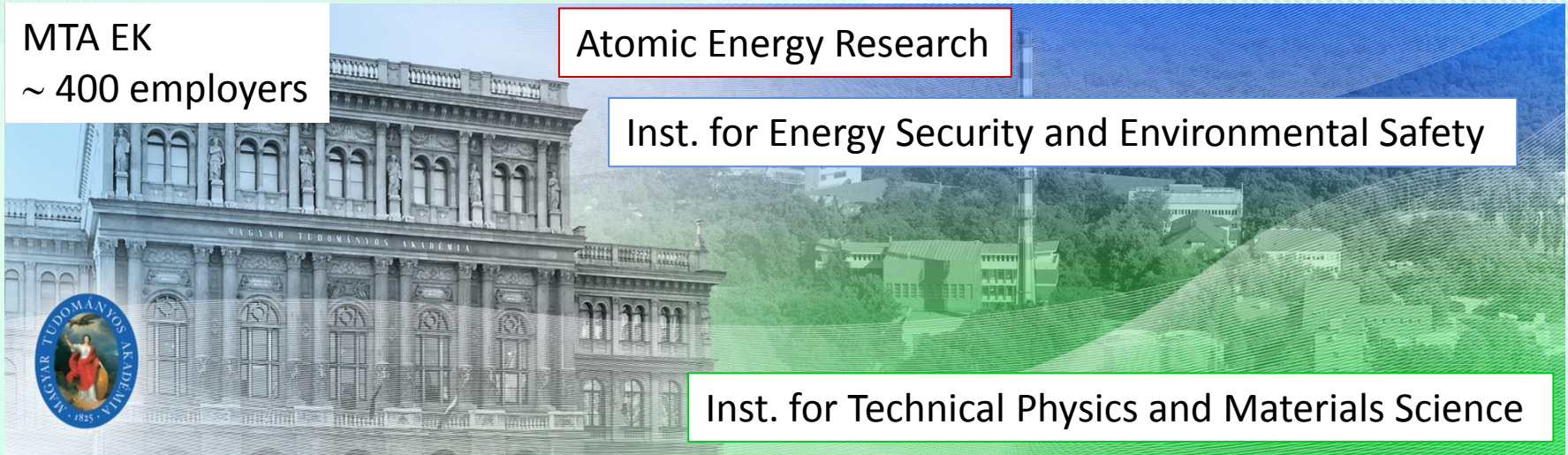
Hungarian Academy of Sciences Centre for Energy Research (MTA EK),  
Budapest, Hungary



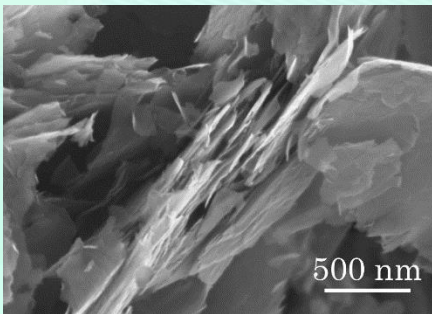
MTA EK  
~ 400 employers

Atomic Energy Research

Inst. for Energy Security and Environmental Safety



Inst. for Technical Physics and Materials Science

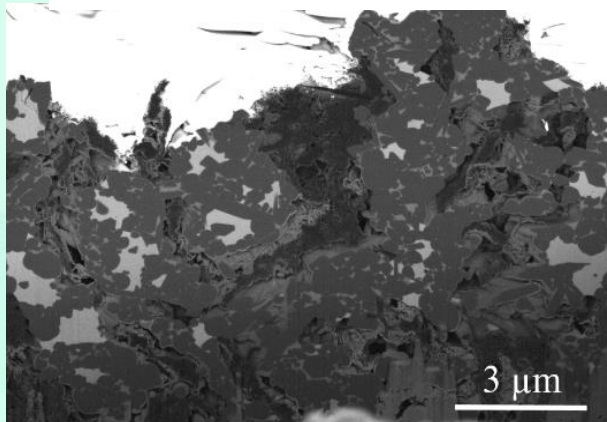


- ❖ Mass preparation of graphene and ceramic matrix by attrition milling
- ❖ Optimization of ceramic / graphene base powder mixtures
- ❖ Structural characterization of composites

Multilayered graphene



**Partner: Prof. Zschech Ehrenfried**  
Division Director  
Institute for Ceramic Technologies and Systems IKTS  
Dresden, Germany



### Contribution to CERANEA

- ❖ Fracture mechanism, crack propagation process, adhesion behavior
- ❖ Mechanical-electrical-microstructure correlation (in-situ)
- ❖ Thermal-microstructure correlation

$\text{Si}_3\text{N}_4/\text{MWCNT}$  composite

**Partners: Prof. Ján Dusza**

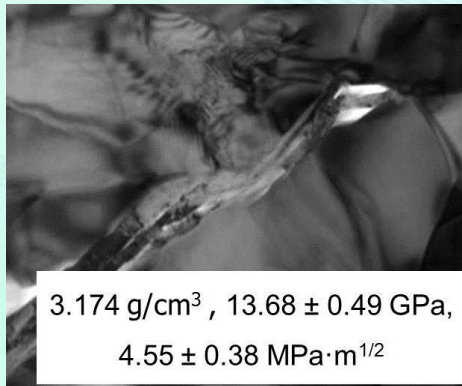
Professor, member of the presidium of SAS  
Institute for Materials Research, Slovak Academy of Sciences (IMR SAS),  
Kosice, Slovakia



The main fields of research activities of the Institute include:

- Advanced steels
- Advanced powder technologies/materials
- Nano-structured materials
- Structural and functional ceramics

Important areas of the IMR SAS activities:



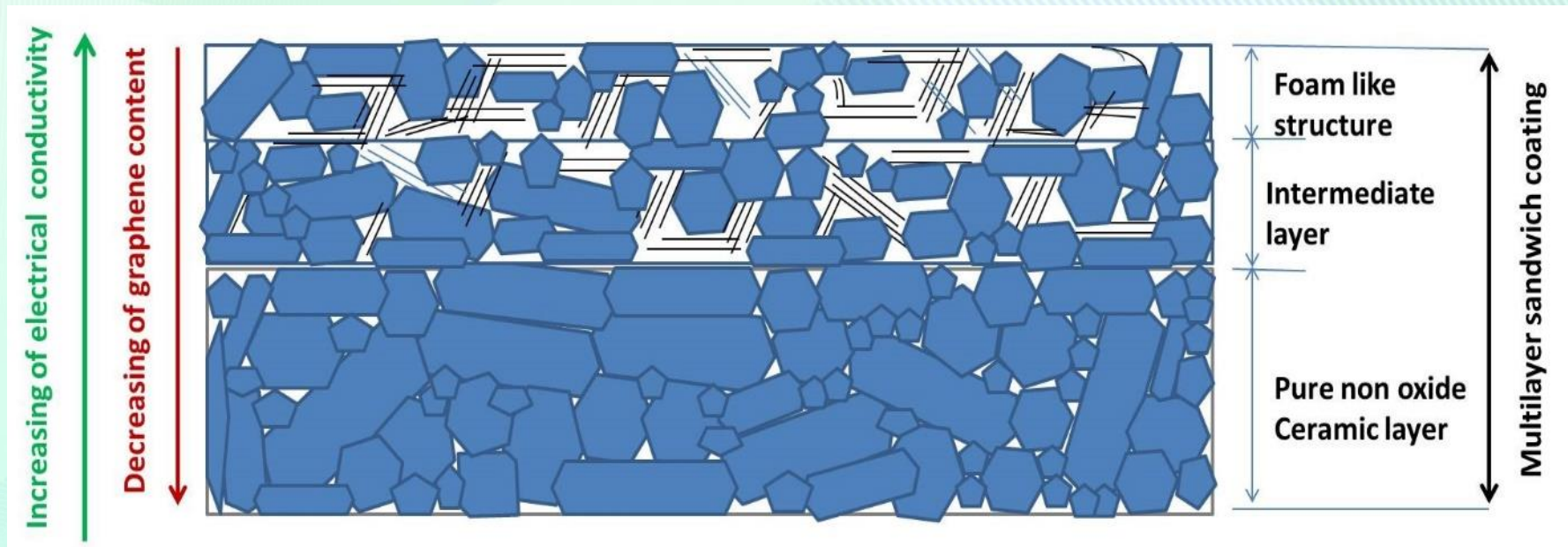
### Contribution to CERANEA

- ❖ synthesis of graphene oxide (GO)
- ❖ Sintering of ceramic/graphene composites
- ❖ Mechanical and Conductivity measurements

Spark plasma sintered  $\text{Si}_3\text{N}_4$ / MLG

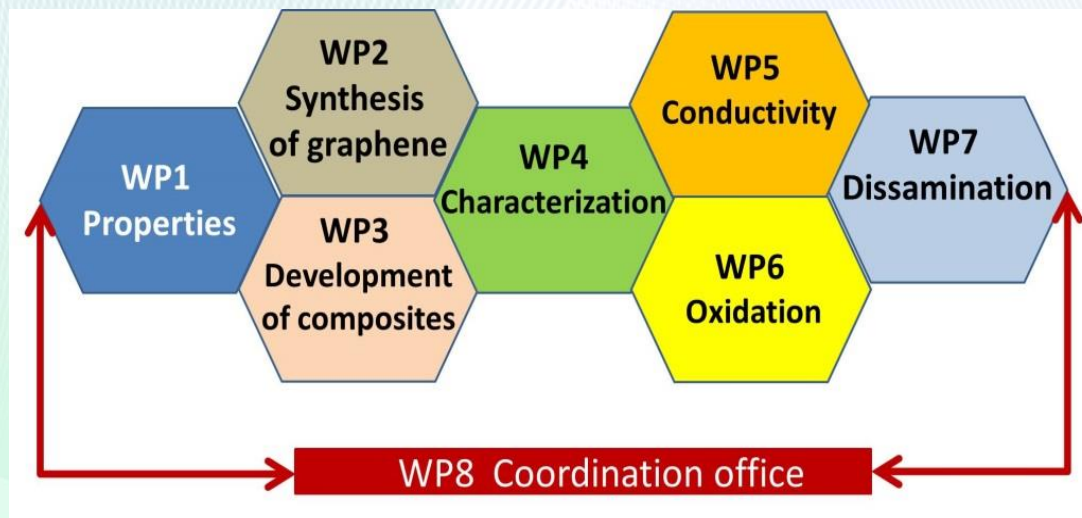


The **CERANEA** project deals with development of the **new multifunctional conductive non-oxide ceramic/graphene thick coatings**, multilayered ceramics for electrical contacts, switches and bring down the barrier using first the existing coating equipment for sample production by using available HIP/SPS technology and defining the parameters for upscaling in parallel.



Design of functionally graded composites (FGM) containing incorporated graphene in sandwich structures with several functional layers-in section

## WORK PLAN



**WP1** - Definition of properties for possible application (M1 – M3)

**WP2** - Preparation and Synthesis of different graphene types (M1 – M9)

**WP3** - Development of ceramic/graphene coatings (M7 – M27)

**WP4** - Characterization of graphene and ceramic/graphene coatings (M4 – M36)

**WP5** - Electrical properties of coatings (M19 – M32)

**WP6** - Thermal properties of coatings (M19 – M32)

**WP7** – Dissemination (M1 – M36)

**WP8** - Coordination office (M1 – M36)



## Expected impacts

- **large scale synthesis of graphene nanoplatelets** will be achieved by use novel approach to encourage the intercalation or expansion of graphite by high efficient attritor mill
- the micromechanical and intercalation based exfoliation of graphite is expected to realize a simple and efficient process, which can lead us to **the mass production of graphene-based materials**
- possible to produce **ceramic materials and coatings with improved mechanical, electrical and thermal properties** by incorporating graphenes into the bulk, thick coating or foam-like ceramic microstructure.
- the electric conductivity of these materials, which is reached already at low (1-5 wt%) and (30 wt%) high graphene contents, offers the possibility to reduce efforts in manufacture and to **create new functionalities** that may be utilized **for technical applications**

The main goal of work will be the development of ceramic/graphene coatings by powder technology as electrical conductive material for new emerging applications and the understanding their preparation-structure-properties relationship with effect on conductive behaviour.





THANK YOU for YOUR ATTENTION!



CENTRE FOR ENERGY RESEARCH  
HUNGARIAN ACADEMY OF SCIENCES