“Resource Materials for Infrastructure – the Smart Specialization Strategy of Ukraine in EU”

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NAS of Ukraine

Kiev 2016

Global Challenges to be responded

- Population is growing in the World and the increase in demand and consumption, mining and processing of material resources is likely to double over the next 40 years. Human impact on the environment in terms of production /consumption irreversibly worsen in case of further exploitation of obsolete production technologies, industry, services and infrastructure.

[1] R. Tommelini Added Value Materials. Cambridge, 2010.

[2] Material efficiency: A white paper by J.M. Allwood, M.F. Ashby, T.G. Gutowski, E. Worrell Department of Engineering, University of Cambridge, Trumpington Street, Cambridge CB2 1PZ, United Kingdom // Resources, Conservation and Recycling 55 (2011) 362–381,

[3] J.M.Allwood, M.F.Ashby Sustainable Materials, 2012 UIT Cambridge Ltd.

- Mineral resources are limited, so ... Mankind is looking for materials that meet the scientific and technical requirements of continuous operation for a long life, long duration determined by reducing their technical and economic parameters to a critical level, and pollution below acceptable standards, and so on.

Global Challenges to be responded

- The deep contradiction between the European Safe Life Concept and real aging infrastructure across Europe (including Ukraine) must be overcome through the creation of new infrastructure using modern materials and technologies long-term use of their operation. Recently it has been stated in FP7 SafeLifeX project:

"Safe use and the subsequent development of European transport, industrial and energy infrastructure faces considerable difficulties due to their age".

EU Standards: Risk-Based Inspection Framework (pwi00319020 CEN TC 319, maintenance).

NMBP-06-2017 «Improved material durability in buildings and infrastructures, including offshore» directly facing reliable materials with extended service resource.

- **Ukrainian scientists are very skilled in the development of the RESOURCE MATERIALS but the Country does not use this potential properly**.

  Space and Nuclear projects of the past century were stimulating the development of exclusive materials, which determined the 70-years progress of Materials Science and the World economy. The main integral characteristic of these materials had been and still remains - their RESOURCE of service under operating conditions.

Challenges specific for Ukraine

Segment of market for RESOURCE MATERIALS (other words Smart Specialization) and Strategy of it's development has not yet been formed in the World – thus, Ukraine has a chance to start forming it first through the initiation and implementation of the EU Program in Horizon 2020 overcoming several barriers:

- **There are scientists, but scattered…;**
- **There are plants and enterprises, but each remains de-focused…;**
- **There are IPRs and technologies, but scattered and non-systematic…;**
- **There is powerful transit potential, but not used properly…;**
- **There is an economically justified need for construction of new infrastructure in the segments of transport, energy, industry of Ukraine as a part of the European infrastructure, but … lacks the support of the State;**

- **Transformation requires concentration of resources : power, scientists and industry (Customers, Developers, Manufacturers and End-users) to solve a complex problem - creating the segment of market named "Materials for Infrastructure" (RESOURCE MATERIALS) to meet requirements of the Global market and Global Challenges to receive Smart specialization in the EU market!**
- **Transformation of new Infrastructure, including transit one, to customer of RESOURCE MATERIALS.**

- Thus, the group "resource material" is focused mainly on durable, reliable and safe exploitation of infrastructure, industry, transport, energy, etc. i.e. the fundament of the economy, in particular, EU countries and worldwide.
- In a number of EU countries and Ukraine, the structure of the basic sectors of the economy strongly differs by quality (the use of resource materials) either duration and safety of operation. Transition of these industries to a new level of quality and diversification will require substantial investment over a number of decades. All the above is a prerequisite for public-private partnerships mechanism, which can be realized within the "Resource Materials" Interdisciplinary Program Initiative.
- “Resource Materials” are invoked to complete new and huge Segment of Market at the level of € 1 Trillion.

Great potential of Ukrainian Materials science & Materials Technologies

National Academy of Sciences

2000 DSc., PhD in 12 research institutes:

Frantsevich Institute for Problems in Materials Science

Paton Electric Welding Institute

Institute of Single Crystals

Institute of Scintillating Materials

Bakul Institute of Superhard Materials

Karpenko Physico-Mechanical Institute

Physico-Technological Institute of Metals and Alloys

Kurdyumov Institute of Metal Physics

Galkin Institute of Physics and Engineering

Vernadsky Institute of General and Inorganic Chemistry

Chuiko Institute of Surface Chemistry

Kharkiv Institute of Physics and Engineering

High School

1000 DSc., PhD in 10 universities:

Shevchenko National University (Kiev)

National Technical University (KPI)

Karazin National University (Kharkiv)

National Technical University (Kharkiv Politechnic University)

National University Lvivska Polytechnica

Franko State University (Lviv)

National Aviation University (Kiev)

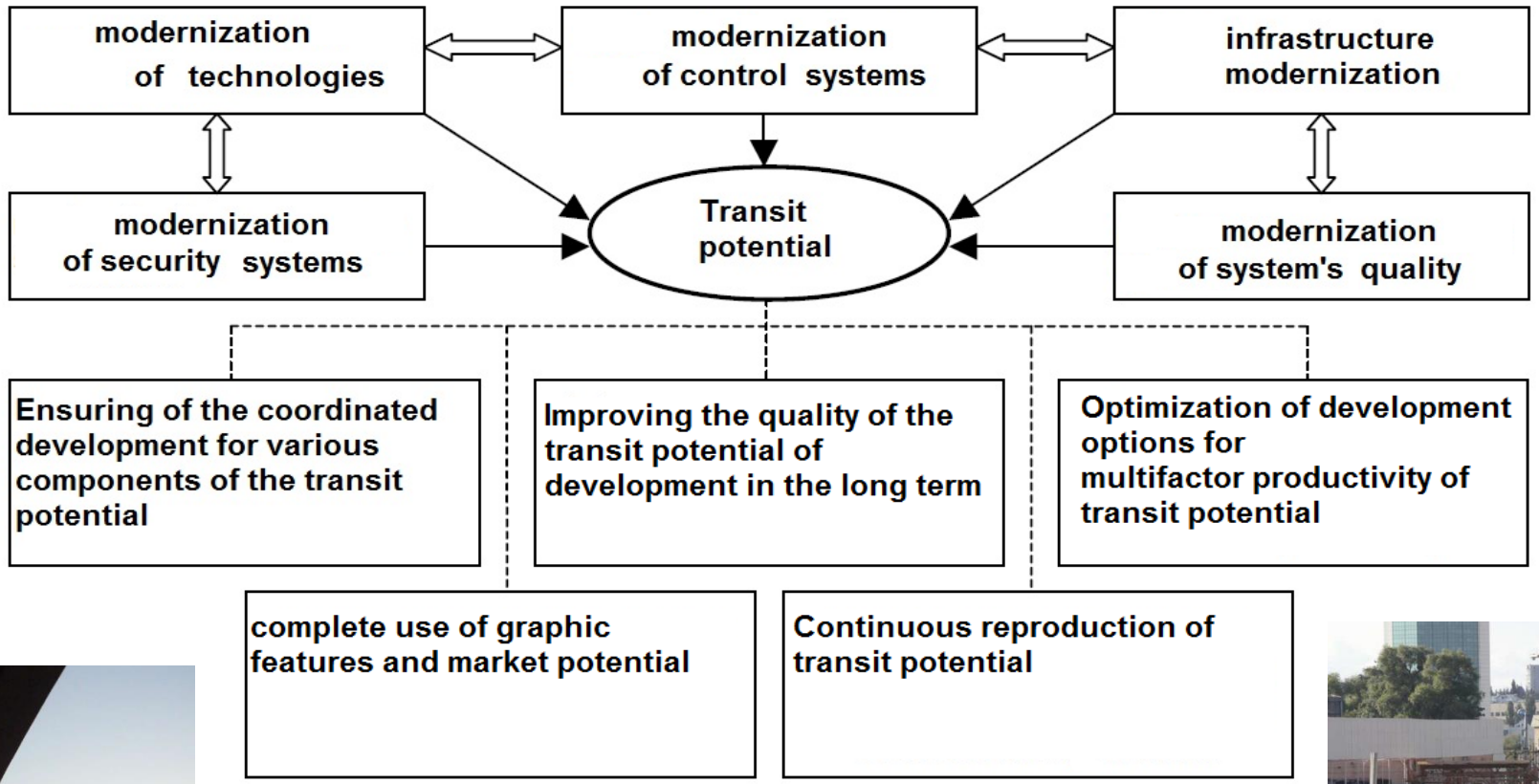
Donetsk National Technical University

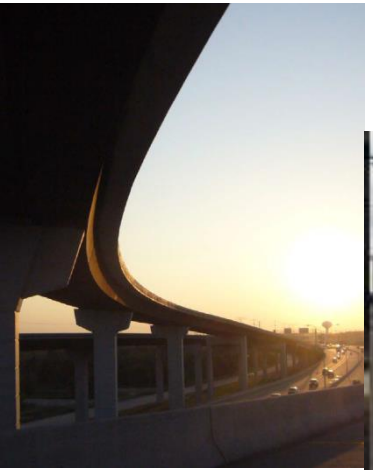
Dnepropetrovsk National University

Kiev National University of Technology and Design

Kramatorsk Technical University

Transit potential of infrastructure in Ukraine -
the largest segment of Resource Materials consumption





Transit infrastructure of Ukraine

- **Ukraine is working over strengthening the position of a transit country.**
- **Ukrainian transit with powerful function is an important factor in the economic development of the EU and strengthening geo-economic and geopolitical position of the EU in the world.**
- **Ukraine is an important transit link in the organization charts in Eurasia, creation and development of international transport corridors.**
- Transportation and road complex country significantly out of date, and must be reconstructed to meet international and European standards.
- Realization of transit potential is closely linked to the operation of international transport corridors.
- Development of Ukrainian infrastructure can not be considered separately from the process of its economic integration in the EU.
- The technical state of vehicles and infrastructure, the level of provision of infrastructure, energy supply and other technical resources and transit consumption depends on the **RESOURCE MATERIALS OF EXTENDED OPERATION IN INFRASTRUCTURE**.
- Based on the systematic theoretical and empirical data it should be defined the objectives for development a dominant strategy: to ensure a high level of functioning of the transport sector; a competitive feasibility of transit (based on international agreements and standards); improve the economic efficiency of the transit sector; adherence to standards of national security, protection of national interests and economic independency of Ukraine.

Advanced Long-Lasting RESOURCE Materials for Transport, Energy, Medicine and Environment Protection

Cross-Cutting Program Initiative

“RESOURCE MATERIALS” in the framework of

Public - Private Partnership (PPP)

in the period 2018-2022

The proposition of the Materials research community of UKRAINE

Interest of EU in PPP Resource Materials

- New segments of materials, technologies and services.
- At least - in Ukraine. As a maximum - New Silk Road
- Infrastructure development EU
- Competitive materials and technologies outside the EU
- Technology and construction of a new level
- Highly skilled jobs in the EU
- New jobs in the EU, developing countries and in Ukraine
- Reducing the social tensions caused by migration
- Reducing the probability of industrial accidents in the EU, developing countries and on the borders of the EU

Interests of Ukraine

- Innovative and integrated Science and Education ...
- **New infrastructure of industry, transport, energy, which is constructed from materials made in Ukraine;**
- Reconstructed industry;
- Changing the structure of the industry;
- The new infrastructure of cities, villages, industrial and transport hubs;
- **Participation in transit Megaproject "New Silk Road" between China and the EU**;
- Create a new transport infrastructure that meets the standards of China's high-speed and EC (electric vehicles, high-speed trains, highways, etc.);
- **The Energy Strategy coordinated with the EU**;
- New energy-generating capacity, energy-accumulating systems, energy-converting systems, improving energy consumption;
- The new system of environmental protection and recycling

Purpose of PPP Resource Materials:

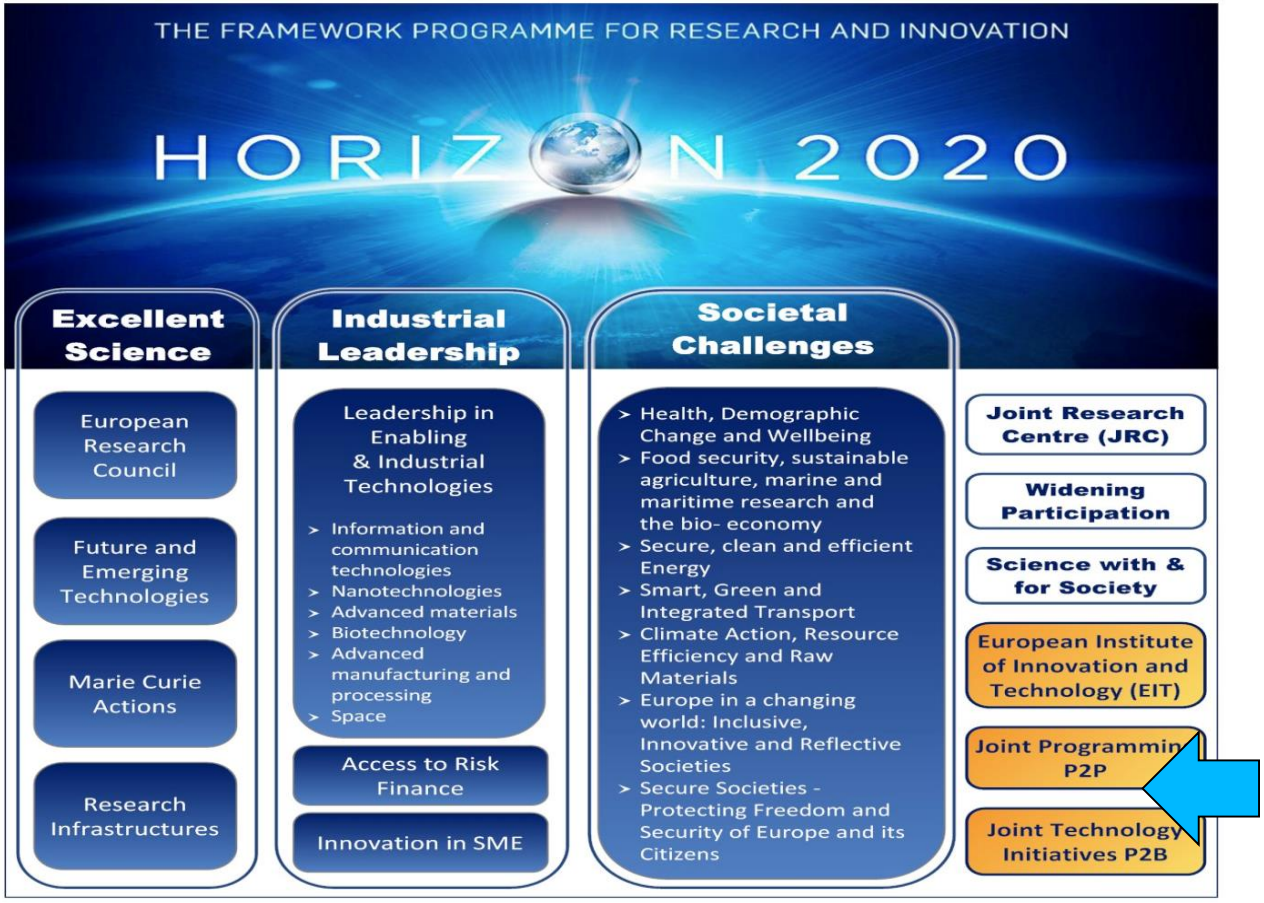
The overall objective of the program - creating new materials segment, critical products and components of products that have increased life service infrastructure energy, transportation, medicine and environmental protection through the implementation of the results of systematic research, implementation of production technologies and subsequent commercialization.

Purpose of PPP Resource Materials:

The sub-objectives are:

- Achieving synergies and interaction between research & education organization and industrial sectors, interested in the solving the problems of infrastructure renovation and industry structure changes, transport and energy on the territory of the private-public partnership;
- Organization of interaction between technological platforms of EU and Ukraine, to transform the infrastructure.
- Definition of the best solutions to be implemented in the new technology infrastructure based on resource materials;
- Definition of strategic research agenda (SRA) and Implementation Strategy (Roadmap);
- Initiating and Development of preliminary standards and standards, as a basement for development of infrastructure.

Place of PPP Resource Materials in Horizon 2020



Connections with PPP Resource Materials

Public Private Partnerships	EU (H2020)	Private Partners
Innovative Medicines Initiative 2 (IMI2)	1 638	1 425
Fuel Cells and Hydrogen 2 (FCH2)	665	380
Clean Sky 2 (CS2)	1 755	2 194
Electronic component and systems (ECSEL)	1 185 (+1170 from MSs)	1 657
Bio-based Industries (BBI)	975	2 730
Shift2Rail (S2R)	450	470
European ATM system (SESAR)	585	1 000
RESOURCE MATERIALS	**1 000**	**1 000**

Markets of Resource Materials consumption

- The development of transit infrastructure with Ukrainian raw materials: steel, cement for a new quality: self healing of high speed rails, carriages, concrete constructions, pipelines etc.
- Creating self-healing concretes for transit high-ways and systems for protection of environment;
- Other metal, and composite ceramic materials for infrastructure of transit NEW Silk Road;
- Materials for Energy Infrastructure as a part of transit infrastructure including local power plants, hybrid accumulating / feeding systems (commutation materials, electric energy transforming / accumulating, lighting systems, etc.
- Materials for systems of heat and water supply for transit infrastructure;
- Materials for industry infrastructure;
- New materials for nuclear power plants, DSS;
- **The segment of materials for infrastructure that is of €1 trillion cost.**

Metal consumption by Infrastructure

- Today, the amount of metal required to lift infrastructure - 300 million tons
- To maintain the current level of metal fond it is necessary the annual consumption of steel products in the domestic Ukrainian market would be not less than 15 Mtons per year
- In the future, the next 10 years in the amount of metal rolling need to upgrade metal fond will be (for major customers, as an example)
- 1. Communal infrastructure (repair of heating, gas pipeline, sewerage networks and wastewater treatment) - 43 Mtons (ie about 4.3 million tons per year)
- 2. Roads state and local value (construction of new roads and major repairs of about 150 thousand kilometers) - 30 Mtons (i.e. 3 Mtons per year)
- 3. Rolling stock "Railways" and private rolling stock (replacement and cover the deficit of rolling stock in amount of 230 thousand units in 10 years) - 5 Mtons (i.e. 0.5 million tons per year)
- It is not considered asset the metal fond for heavy industry, which is about 100 million tons
- *SE“Ukrpromvneshexpertize" Director – Dr. Vlasyuk Kiev, 60 Artem str., off.310-319, fax (044) 484-64-83, e-mail expert@expert.kiev.ua, www.expert.kiev.ua*

SUSTAINABLE DEVELOPMENT GOALS

17 GOALS TO TRANSFORM OUR WORLD

Goal 9: Build resilient infrastructure, promote sustainable industrialization and foster innovation

Investments in infrastructure – transport, irrigation, energy and information and communication technology – are crucial to achieving sustainable development and empowering communities in many countries. It has long been recognized that growth in productivity and incomes, and improvements in health and education outcomes require investment in infrastructure.

Inclusive and sustainable industrial development is the primary source of income generation, allows for rapid and sustained increases in living standards for all people, and provides the technological solutions to environmentally sound industrialization.

Technological progress is the foundation of efforts to achieve environmental objectives, such as increased resource and energy-efficiency.

Without technology and innovation, industrialization will not happen, and without industrialization, development will not happen

Global Economy and Development at BROOKINGS

THE NEW CLIMATE ECONOMY
The Global Commission on the Economy and Climate

Grantham Research Institute on Climate Change and the Environment

We are talking about a new market segment, including material's market!

- **90 trillion will be invested into infrastructure worldwide for 15 years** that is $ 6.7 trillion annually in accordance to report "*Driving Sustainable Development Through Better Infrastructure: Key Elements of a Transformation Program (Global Economy & Development*", Working paper 91, July 2015 under Ed. Lord Stern).

- **For the construction of new infrastructure new materials are requested** and new technologies of production, processing, use and maintenance of infrastructure, business infrastructure, consuming these innovations and qualified to operate them.

- **Group "Materials for Infrastructure" focused on infrastructure, industry, transport, energy, space objects future and protect the environment and human health, safety and reliability is the base of the economy, particularly the EU and Ukraine as well as security and the health of their citizens.**

Global Economy and Development at BROOKINGS

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We are talking about a new market segment, including market materials!

All the above is a prerequisite for public-private partnership that can be implemented under the PPP program of interdisciplinary initiative "Resource Materials" under Horizon 2020.

Development, manufacture and commercialization of resource materials could be part of SMART SPECIALIZATIONS for UKRAINE in EU

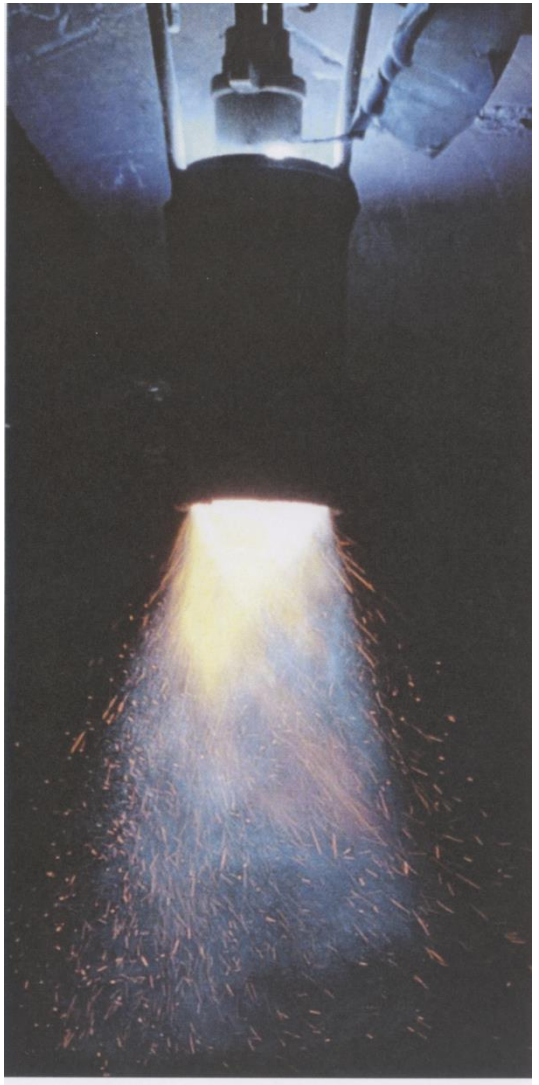
Examples of achievements in Ukraine

Ukrainian Hot Topics:

Advanced high temperature parts for energy applications (including refractory metals and ceramics)

Fields of applications UHTC based on borides:

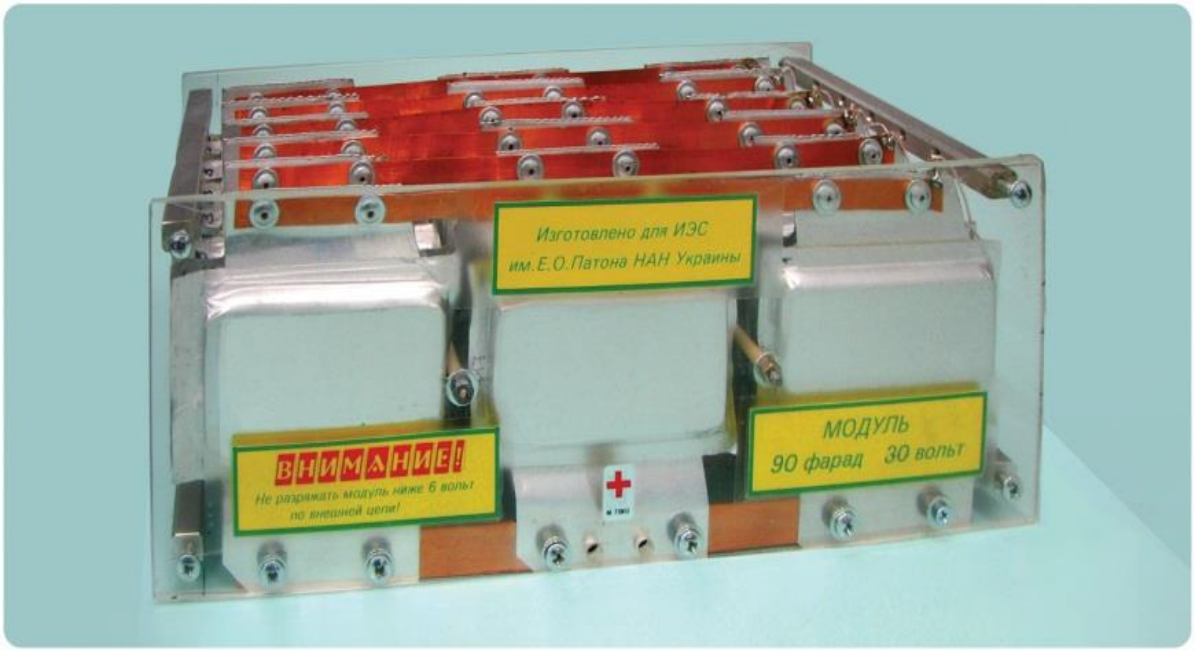
1. Parts for turbine engines
2. Materials for airspace apparatuses
3. Materials for nuclear energy production
4. Basalt fibers production
5. Coal-fired burner tube for electric power stations and heat plant



Production of Supercapacitors (SME Unasco-Ukraine)

Superior Specific Power (to 80-90 kW per 1 kg, efficiency 80%), Durability (more than 30 years), Operation even at low temperatures (to - 40 ºC), high efficiency, use of suitable Ukrainian raw-materials

UNASCO-Ukraine has signed an agreement with Paton Electric Welding Institute **to manufacture feeding modulus** for new welding apparatuses (**90 F, 30 V, 4 mΩ**).



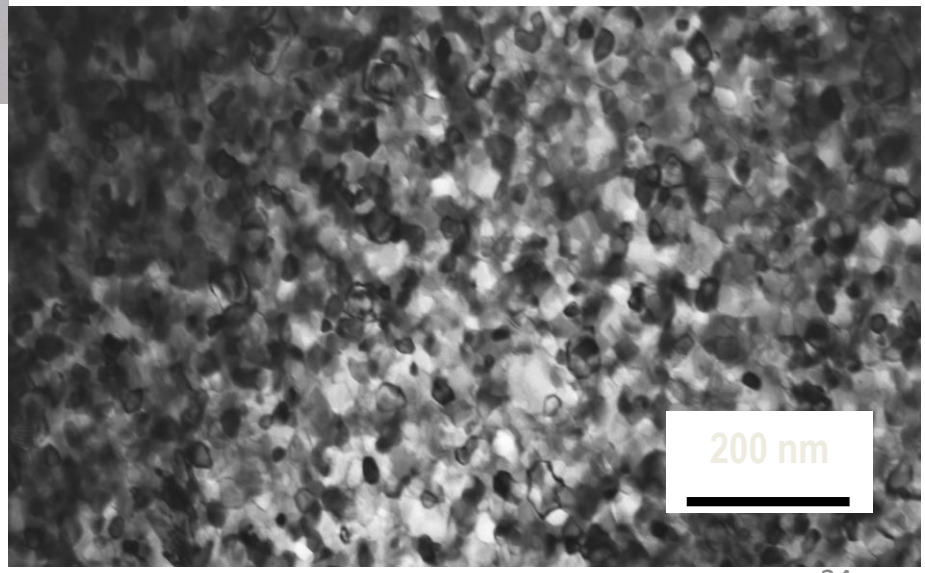
SUPERCAPACITORS produced by UNASCO-Ukraine have been tested and certified in the laboratories and private companies:
Institute of Transportation Research, University of California, Davis (2006-2010)
Engineering Company, developing products for sport bolides (2008-2010)

Ukrainian Hot Topics:

Advanced light weight alloys and composites for aero-space applications.

Alloys of the system *Al-Fe-Cr-Ti* respond to the requirements of today's aviation industry

$\sigma_в$ > 1450 MPa at 300 ˚C; δ > 5 % at room temperature

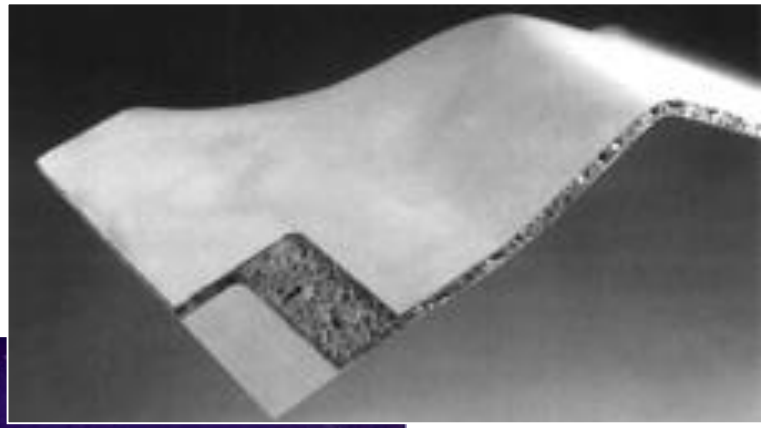


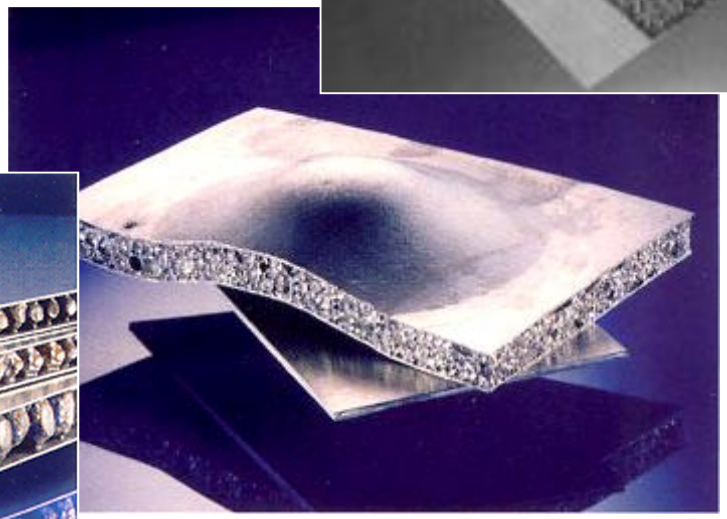
Structure of quenched and crystallized ribbon Al-Ni-Ce-Fe, Annealing at temperatures higher than 350°C

Pilot production Sandwich Panels of Al-Foam

- Building Industry
- Automotive Industry
- Railway Industry
- Aerospace Industry
- Ship building
- Machine Construction
- Furniture Design

Light weight and Enhanced Stiffness





Closed-cell Al Foam

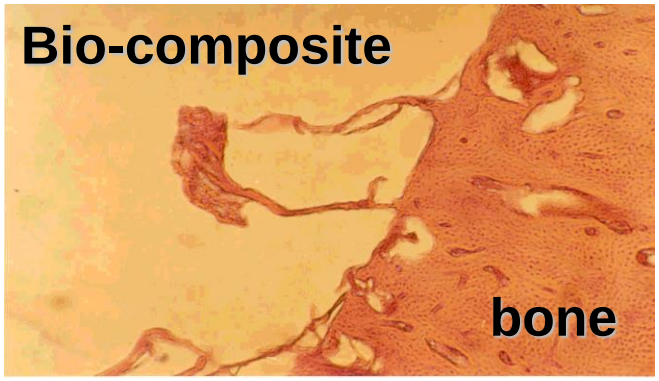
- Crash Energy Absorption
- Noise Control (range of 1-5 kHz)
- Electromagnetic Shield
- Heat insulation
- Sound absorption

Pilot production of implants:

Biomaterials serving as biomarkers, bio-implants, and target drug delivery systems.

Implants from “Synthebone” bionanocomposite

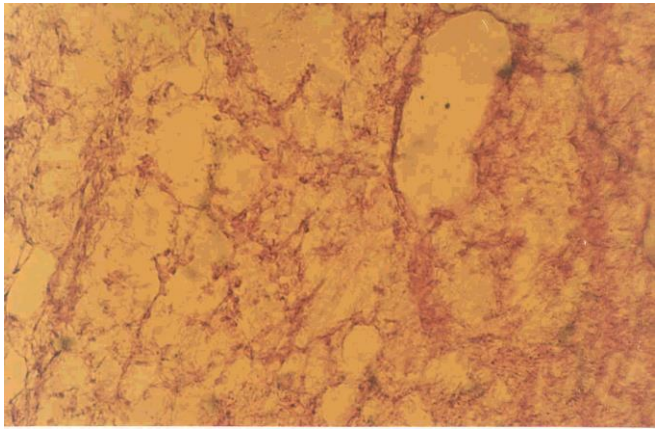
Implant samples



Initial stage

CLINICALLY TESTED

Bio-nanocomposite demonstrates accelerated growing through the implant of natural bone due to the mechanism of dissolution-re-precipitation



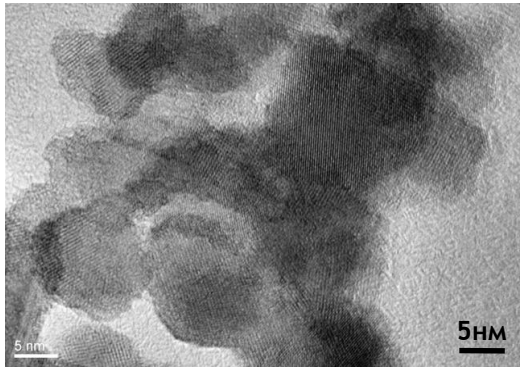
Final stage

Pilot scale production of photocatalysts:

Materials for environmental protection, including active membranes, filters, coatings and sorbents for efficient water and air cleaning

Nano-titania from Ukrainian raw-materials

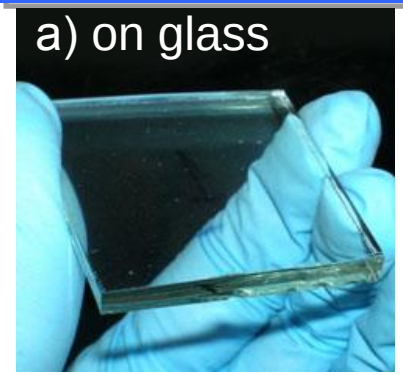
1. Nanosize powder of titania

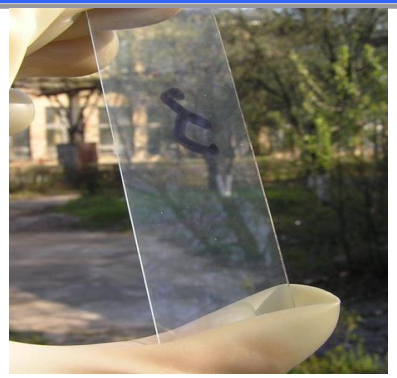


Particle size of TiO_2 is around 10 nm for…

2. Self-cleaning coatings

a) on glass





Deposited from vapor… from dispersion

b) on metals… concrete, ceramics

Stainless steel

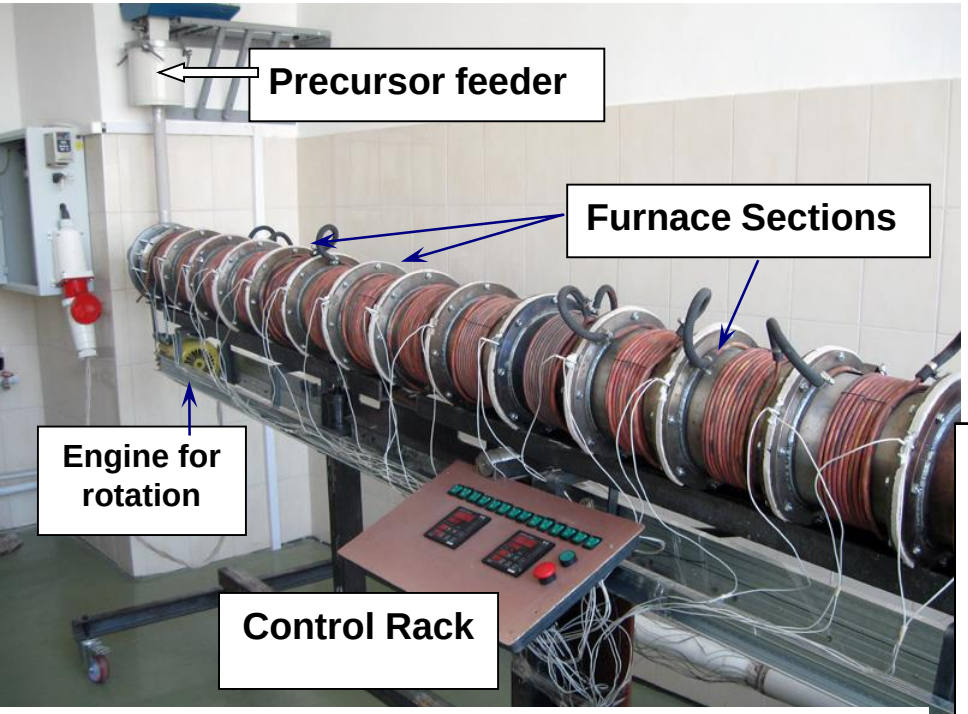
Ceramics

3. Electrolytic solar elements (photocatalysis)

Pilot production of Nanoparticles:

Ceramic nanoparticles for multifunctional applications

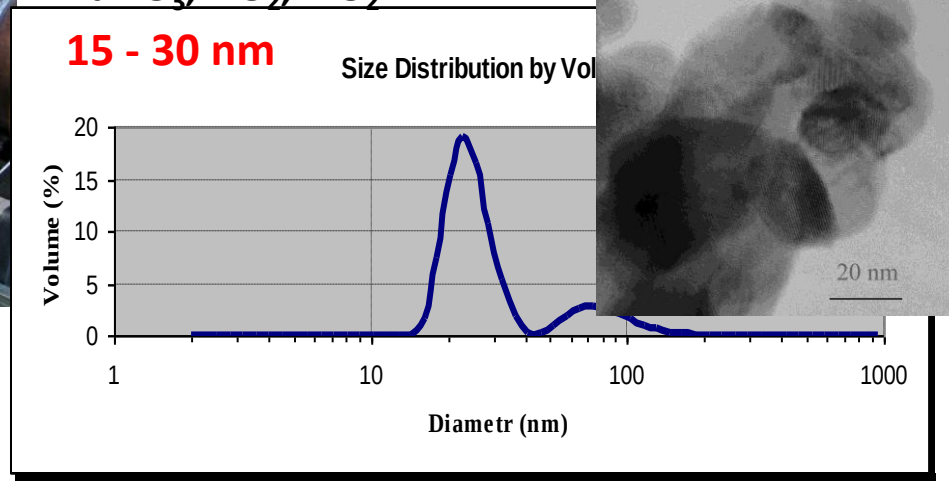
Pilot production from Ukrainian raw-materials



Rotary-tube furnace of continuous operation yielding 25-30 t/year of barium titanate nanopowders

$BaTiO_3$, TiO_2, ZrO_2...

15 - 30 nm



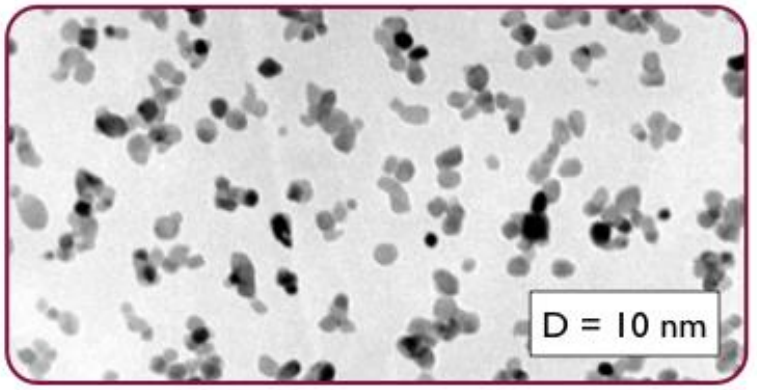
Nanosize Barium Titanate for multilayer ceramic capacitors smaller than 0101 series

IPMS NAS of Ukraine

Pilot production of ZrO2 nanoparticles

Technology provides

- Soft-agglomerated Zirconia nanopowders
- Particle size distribution in the range 5-50 nm
- Narrow Particle size Distribution
- Given phase and chemical composition



The technology provides pilot production of Zirconia-based nanopowders containing various dopants to be used in structural and functional ceramics.

Developed in Galkin Physicotechnical Institute, Donetsk, Ukraine