IMPROVEMENT OF THE PROPERTIES OF MICRO-NANOCOMPOSITE MATERIALS: MYTH OR REALITY?

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Main areas of applications in buildings

- Thermal insulation, UV protection, noise reduction / surface coatings
- Steel and cement-bound construction materials / high performance structural materials / Ground stabilization materials
- Paints, adhesives, sealants
- HVAC systems – BIPV, air filters, water treatment systems, purifiers, fire protection
- Smart buildings / Lighting and electric systems and components

Thermal insulation, UV protection, noise reduction

- Aerogel based insulating materials
- Vacuum Insulation Panels (VIP)
- Photocatalytically active concrete products and coatings
- Latent heat storage ("Phase Change Materials", PCM) – temperature regulation
- Ultra Violet (UV) absorbing, self-cleaning, and depolluting coatings for windows
- ultra-thin layers made of advanced nanoceramics can reduce heat and ultraviolet light transfer
- nano films (15−20 nm) made of microcrystalline titanium dioxide, that (in the presence of UV) produces radicals that degrade organic pollutants to nontoxic products

Building Materials

- steel / corrosion resistant construction steel, nano-reinforcements in steel
- concrete / low energy cement, novel, non-traditional binders, ductile cements & tougher concrete, nano-layers/coatings
- repair mortar for concrete repair work
- ceramics, bricks / bio-active surfaces, tougher ceramics
- glass / self-cleaning glass
- bitumens, polymers / nanofillers, molecular assembly of new polymers
- timber / modified wood for construction, fast growing defect-free, dense/strong

High performance structural materials

- Ultra High Performance Concrete (UHPC)
- carbon nanotubes, new fibre reinforcements, nanocomposites, advanced steels and concrete/cement composites
- biomimetic materials
- concrete, bitumen, plastics modified with nano-particulate additives, special admixtures and new processing techniques modifying internal nanostructures
- Materials with extended durability in extreme service conditions.

High performance new coatings, paints and thin films

- wear-resistant coatings, durable paints
- self-cleaning (to break down organic dirt) and anti-graffiti coatings
- active nano-coatings
- anti-bacteria: silver nanoparticles bound to paint
- safety and security
- smart materials: shape memory, self-repairing, strain hardening, composites with self-adjusting interfaces, novel, controlled and durable fracture mechanisms

HVAC systems – filters, water treatment systems, purifiers

- Building Integrated Photovoltaics (BIPV)
- Fibre-optic and microchip control systems
- Fire protection systems
- Air and water purification systems, efficient filters/membranes and catalysts
- Antimicrobial durable nano-coating resistant to cleansing chemicals and nonflammable

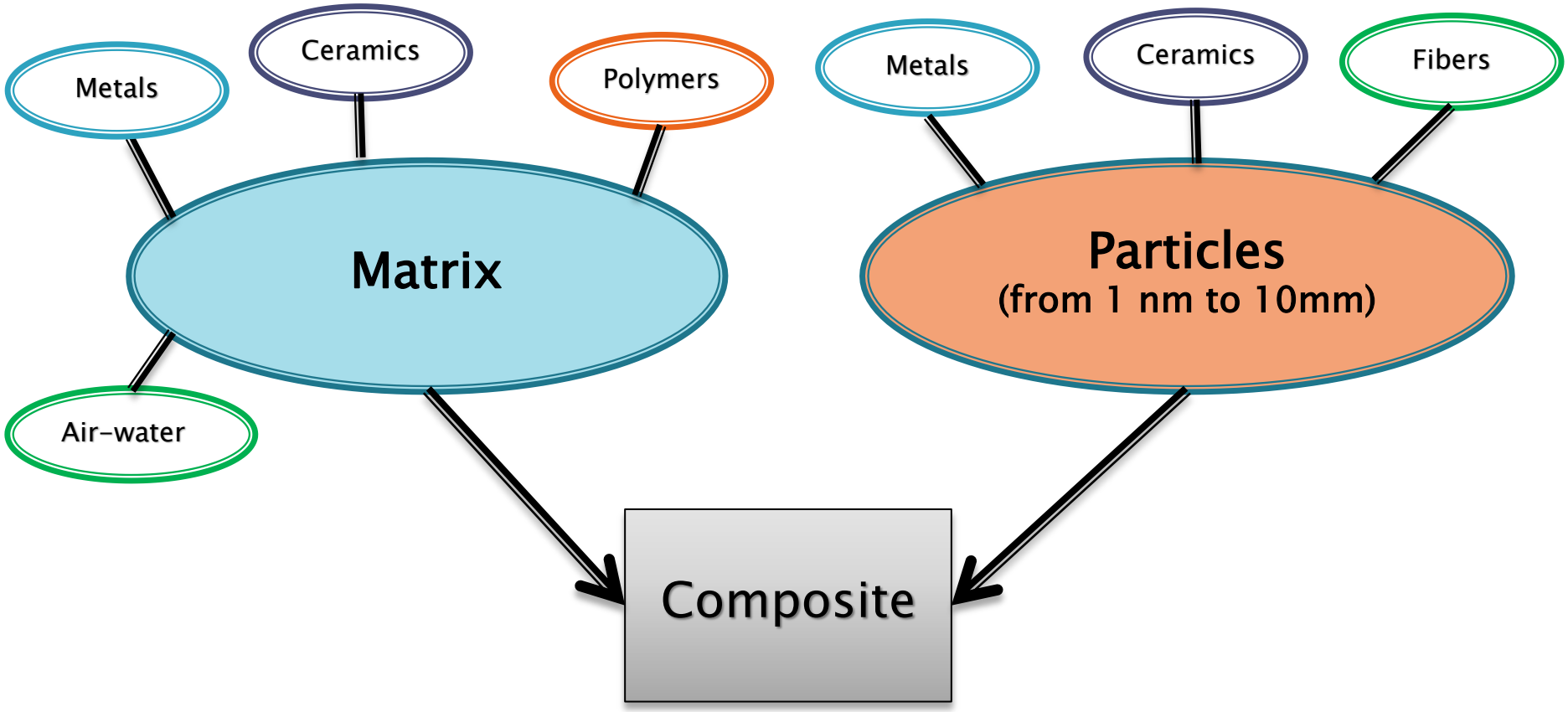
Smart buildings

- Lighting and electric systems and components: energy saving lighting, efficient fuel cells and photovoltaics
- Communication devices, intelligent structures and use of micro/nano sensors: nano-electromechanical systems, biomimetic sensors, paint-on sensors, and self-activating structures/components
- Integrated monitoring and diagnostic systems, monitoring structure defects and reinforcement corrosion, environmental changes/conditions, and detecting security risks

Other applications

- Ground stabilization materials in hydraulic engineering projects and sewer canal construction, as well as in dam and landfill site construction
- Materials for roofs & cladding
- New production techniques, tools and controls, environmental friendly production of materials

What are composite materials?



Some main advantages of micro/nano-composite materials

Increase of mechanical Strength ➡ weight reduction

Increase of electrical conductivites of copper ➡ reduction of energy losses

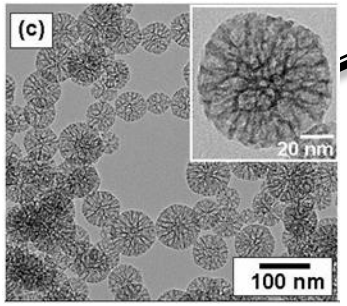
Highly thermal insulating materials ➡ reduction of thermal losses

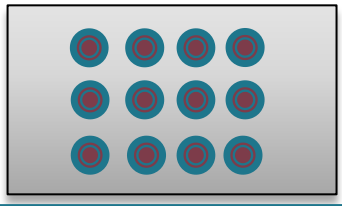
Special thin coatings e.g. UV filtering

Striking example of nano-composite materials : aerogels

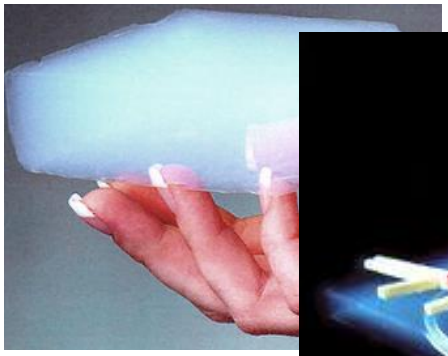
air

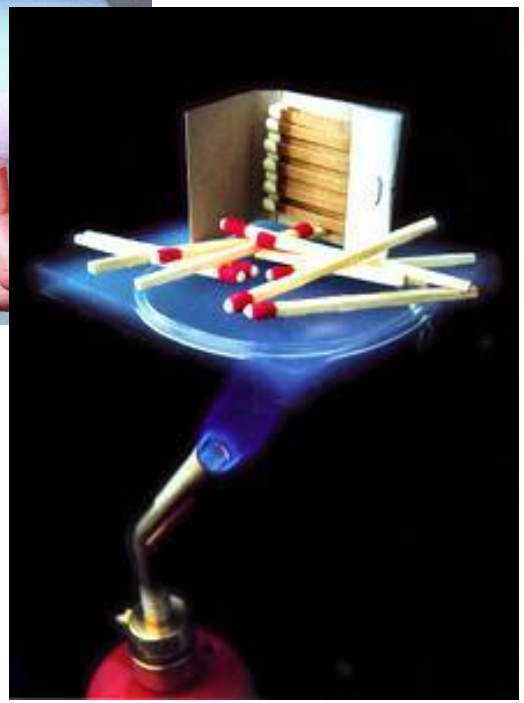
SiO_2 particles





Particle Air Matrix Composite



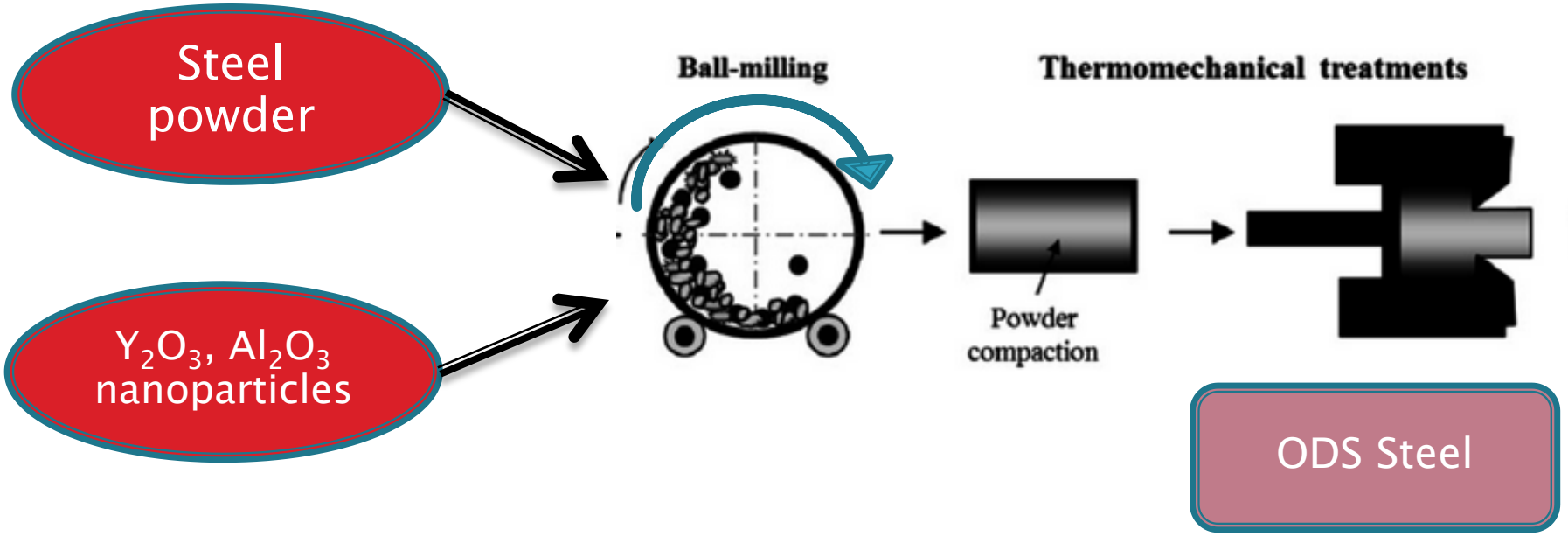


advantages

Highly insulating material, Low density, quasi-transparent, high strength

Striking example of nano-composite materials : ODS Steel

(Oxide-Dispersion Strengthened Steel)



advantages

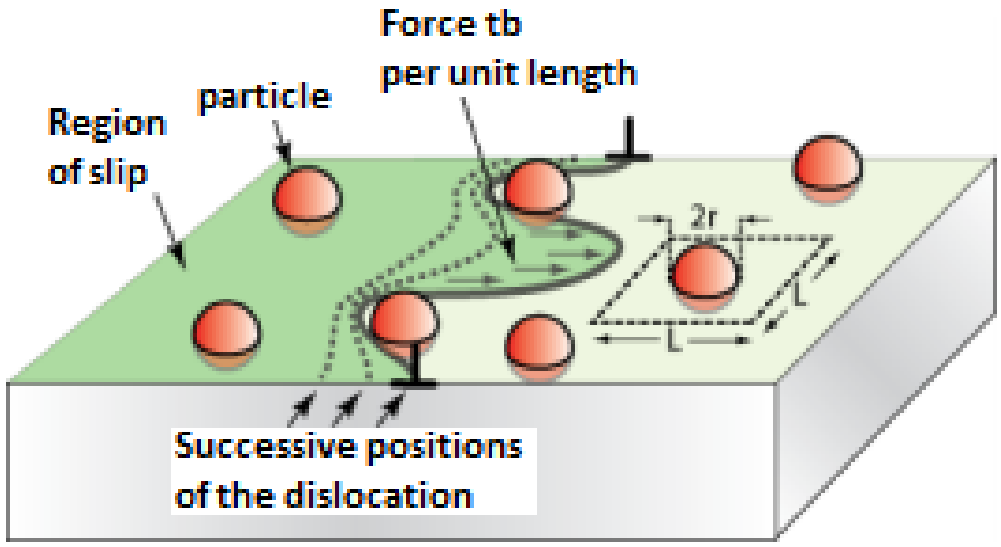
High creep properties, high strength

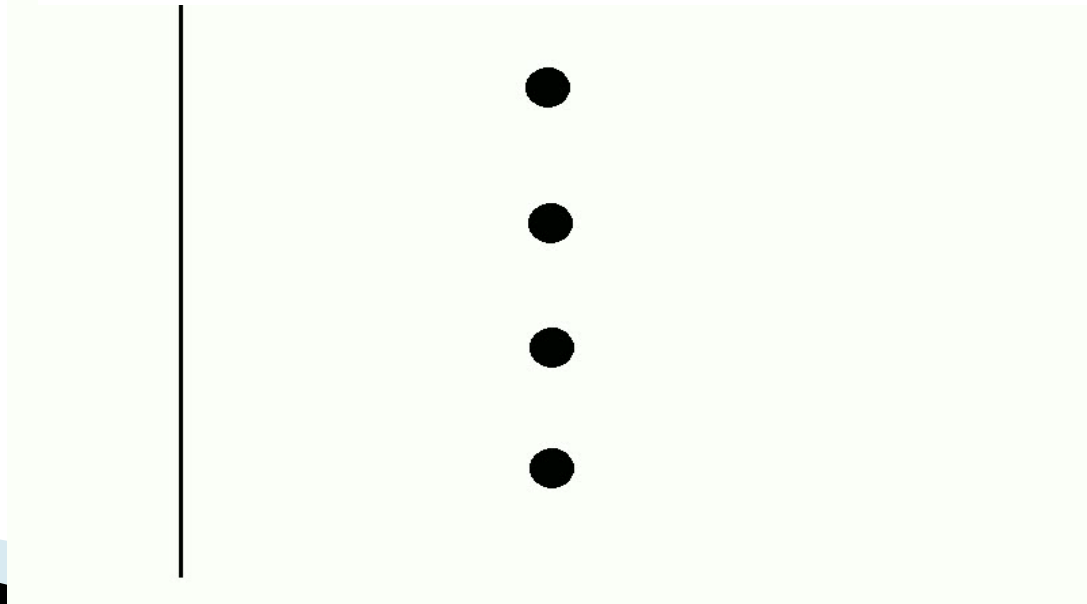
Resistant to harsh environmental conditions

Solution for the future fusion reactor blanket

Various mechanisms of reinforcement : action on dislocations

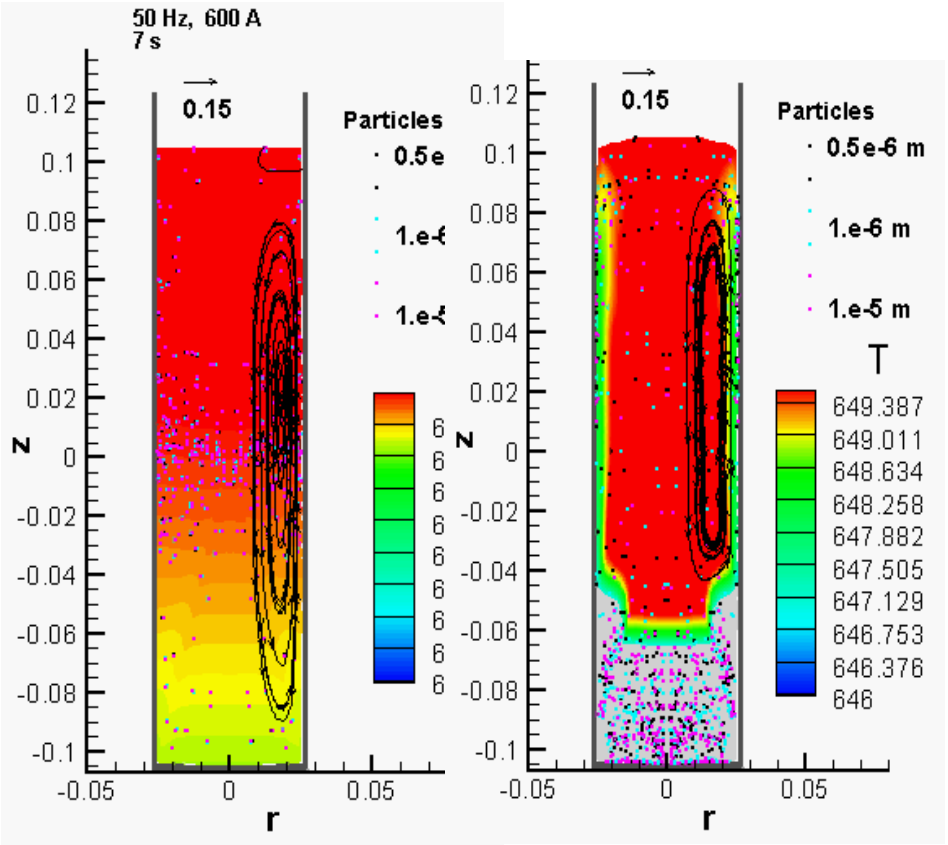
- Load transfer
- Orowan
- Hall Petch



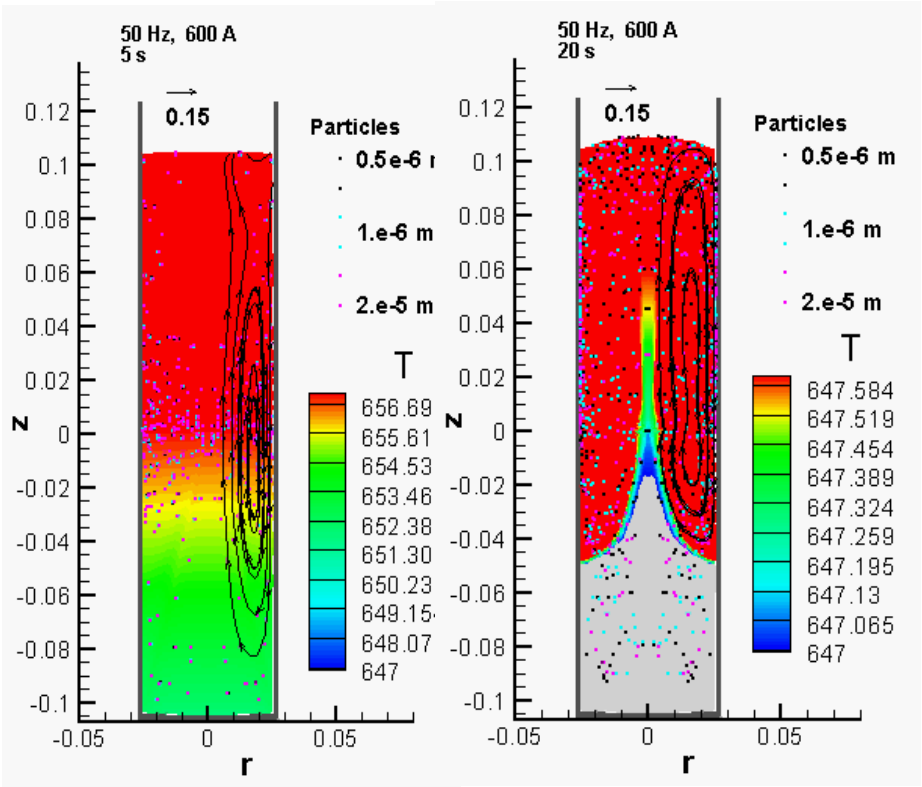


Dispersion of SiC micro-particles during solidification of liquid Magnesium under stirring

Numerical simulation Pure Mg + 1% SiC Upwards vs Downwards TMF



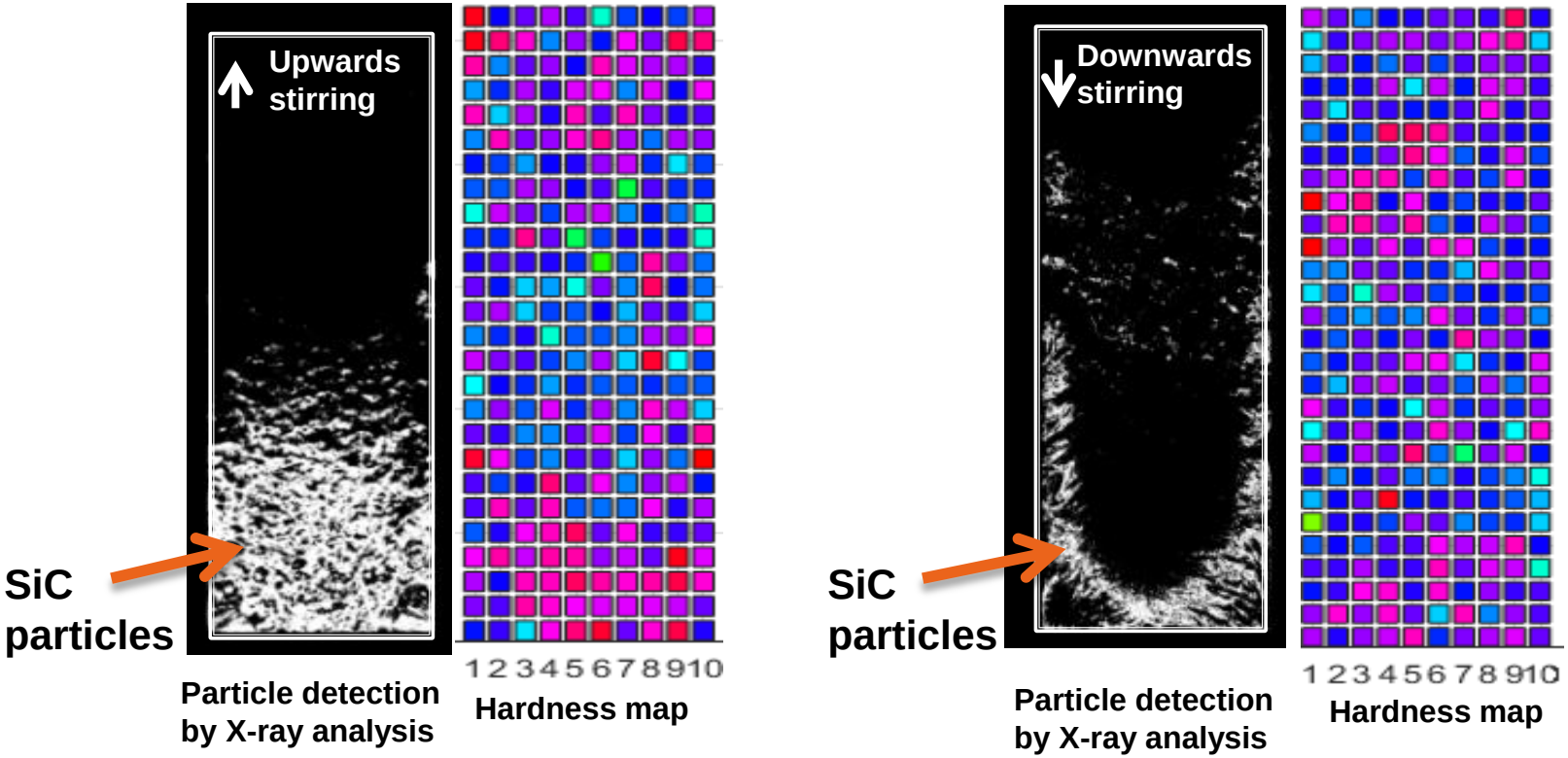
Mg SiC Upwards stirring



Mg SiC Downwards stirring

Dispersion of microparticles : experimental evidences

Particle dispersion under Upwards vs DownwardsTMF Mg +1 % SiC particles 0.1-1µm

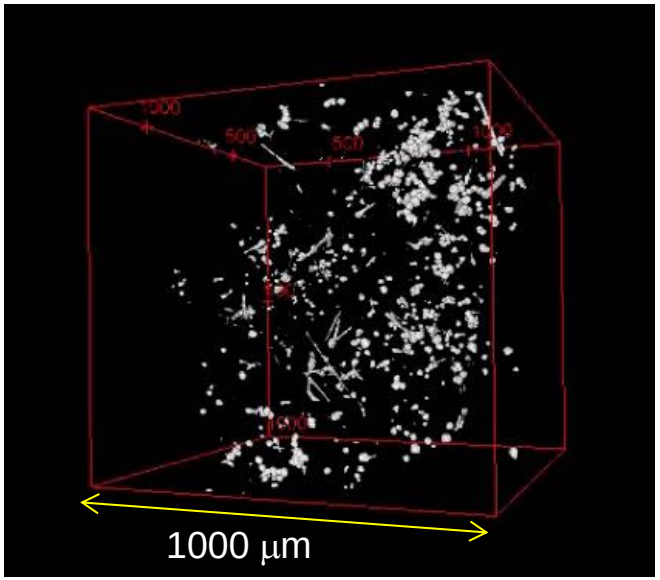


partial conclusions

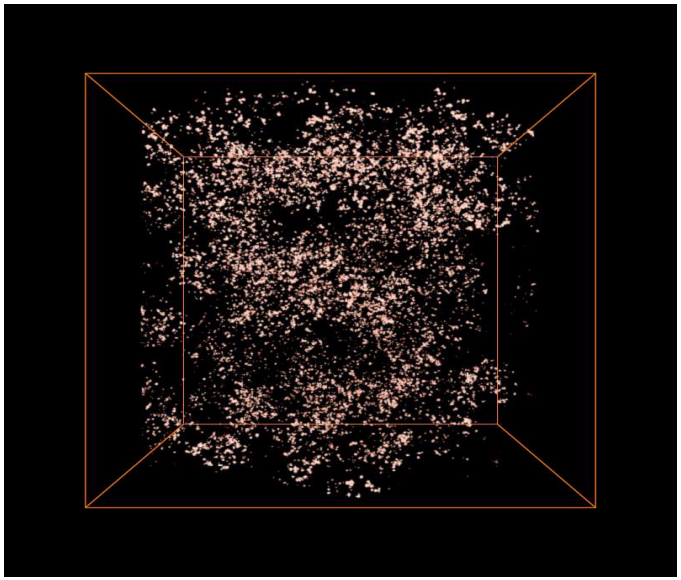
- It is difficult to produce a homogeneous dispersion even with stirring

Grain refinement using Alumina microparticles in Magnesium

Particle dispersion with stirring - Analysis using X-ray tomography



Mg AZ91



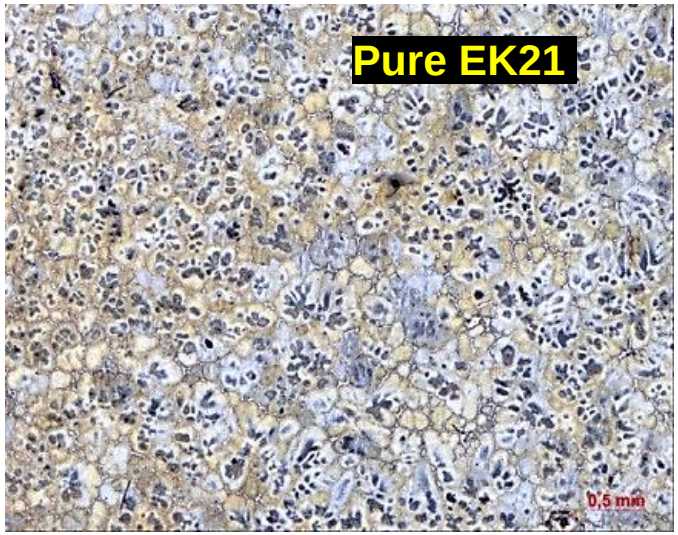
Mg AZ91+1% Al_2O_3

Partial conclusions

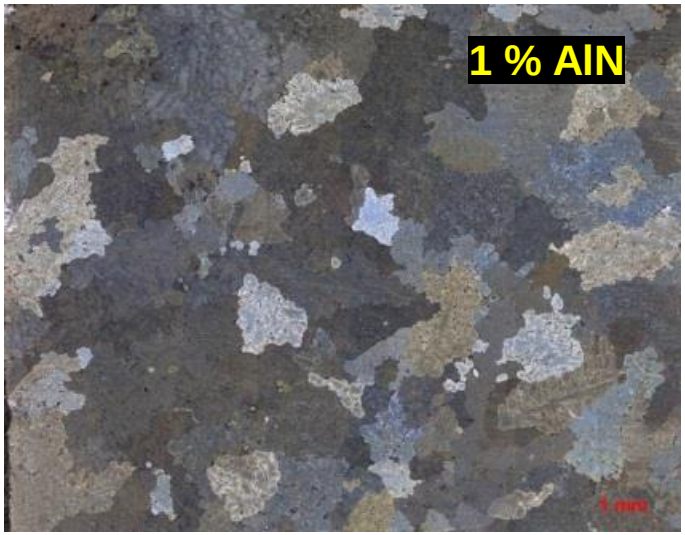
- Reduction of grain size with Al_2O_3 particles
- Metallurgical structures are modified
- No real improvement of mechanical properties

Reinforcement using Nanoparticles

Magnesium EK21 + 1% AlN nanoparticles 30-40nm



Grain size 300 µm

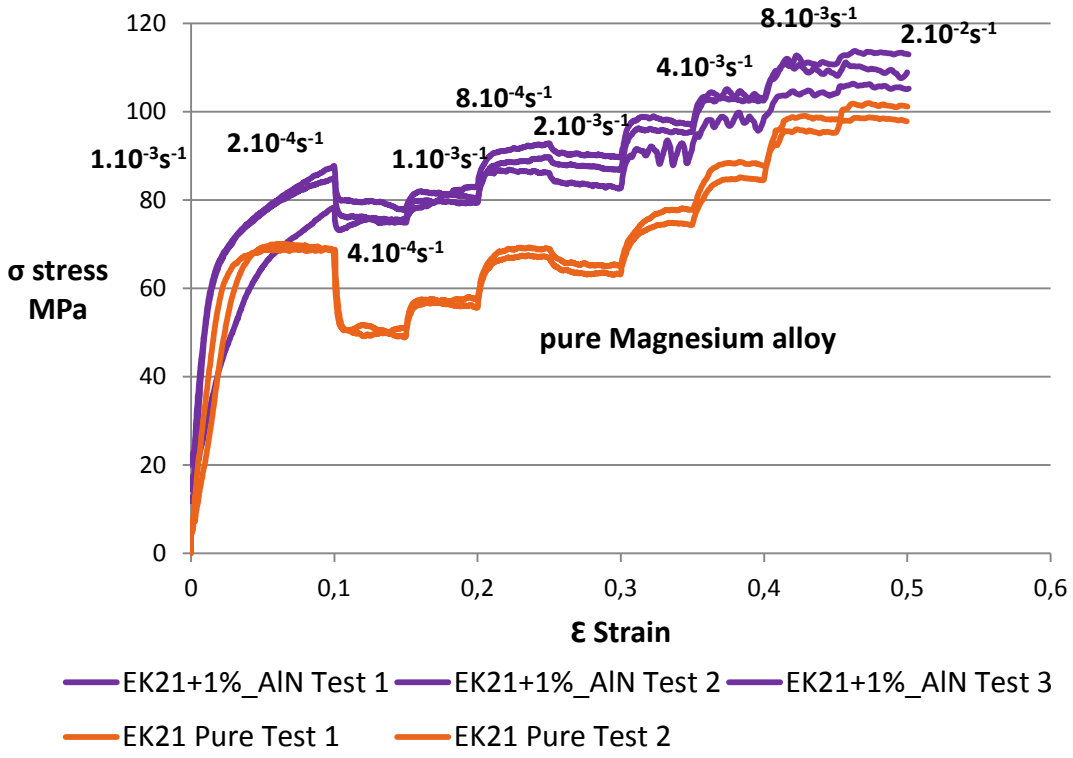


Grain size 1500 µm

Grain size increased in magnesium EK21 containing AlN nanoparticles

Mechanical characterization : reinforcement using AlN nanoparticles in Magnesium

Study of creep and flow behaviour : hot compression curves



Partial conclusions:

- Improvement of the mechanical properties

- increase of the creep resistance

General conclusions

- Composite (MMC) materials offers interesting perspectives in various areas like building construction, automotive industry, nuclear industry

- Large-scale production still remains a challenge due to various issues to be solved, like particle embedding, homogeneity, process complexity

Thank you for your attention

Vo multumesc pentru attentie

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