Development of Advanced Magnesium Alloys for Multifunctional Applications in Extreme Environments (MagMAX)

Project team

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Institute of Materials Research
Slovak Academy of Sciences

BioMaterials Group
Faculty of Materials Science and Engineering | Warsaw University of Technology

ELTE
EÖTVÖS LORÁND UNIVERSITY

KATEDRA FYZIKY MATERIÁLŮ
DEPARTMENT OF PHYSICS OF MATERIALS

Motivation – engineering applications

Conventional magnesium alloys

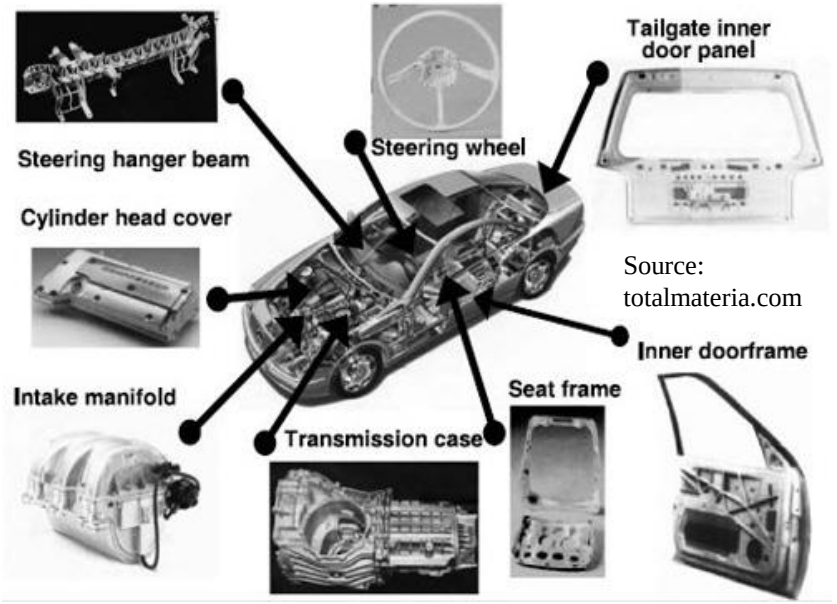
Advantages

- Excellent strength-to-weight ratio → fuel saving
- Recyclability
- "Unlimited" source

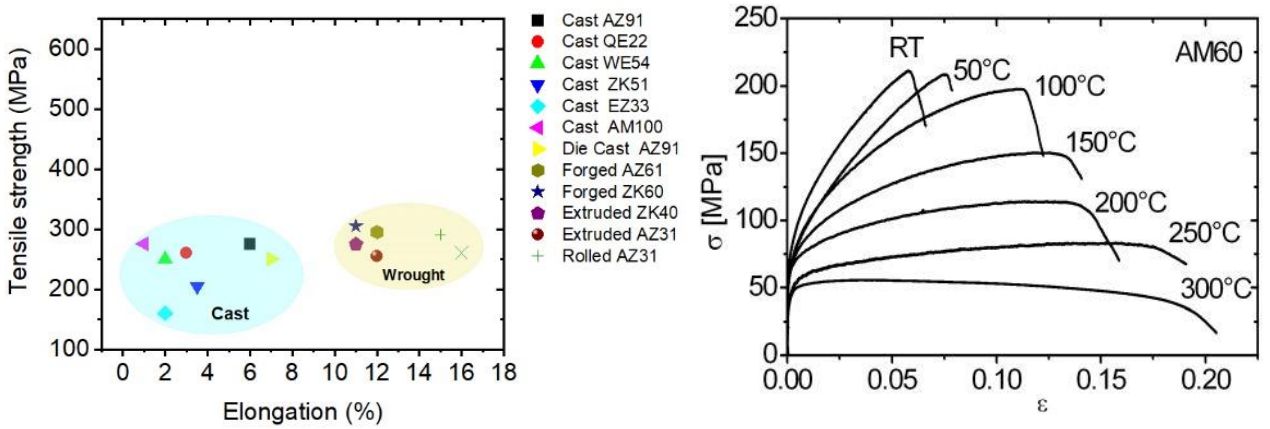
Disadvantages

- Low to moderate strength
- Degradation of mechanical properties above 150 °C
- Safety issues (flammability, high corrosion rate)

Improvement of mechanical and physical properties



Source: totalmateria.com

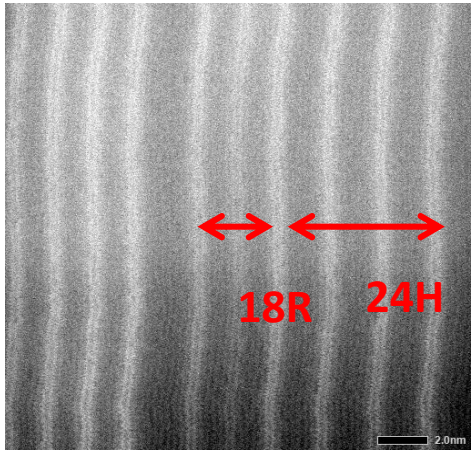


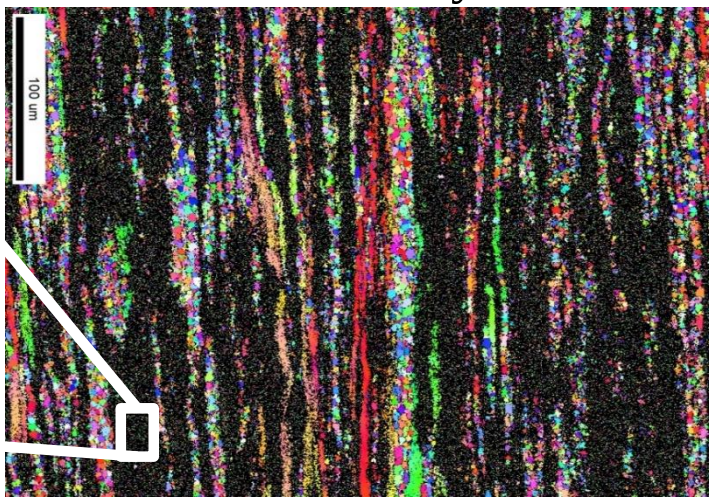
Motivation – engineering applications

Possible solution

Magnesium alloys with long-period stacking ordered structure (LPSO)

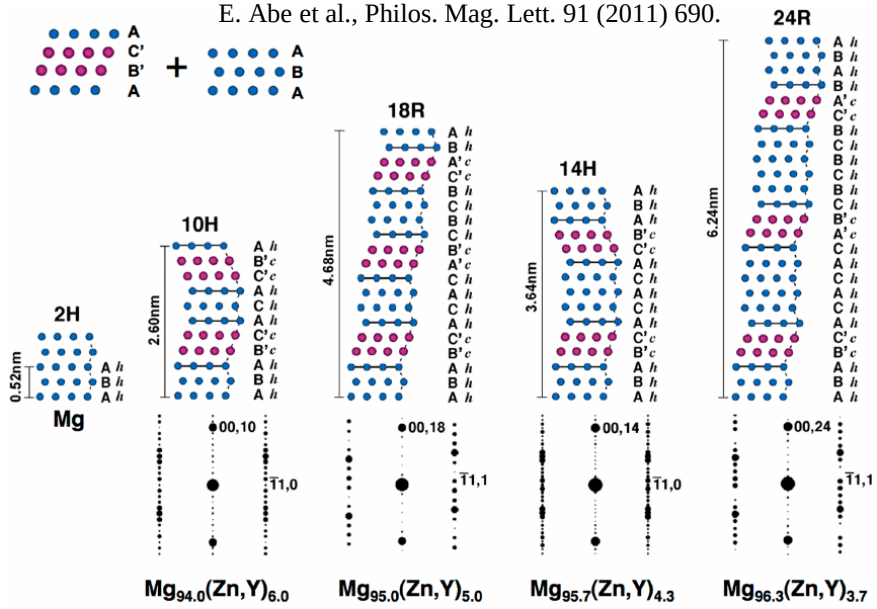
- Mg-Rare Earth-Transition Metals alloys
- Composite-like structure – hard + soft layers

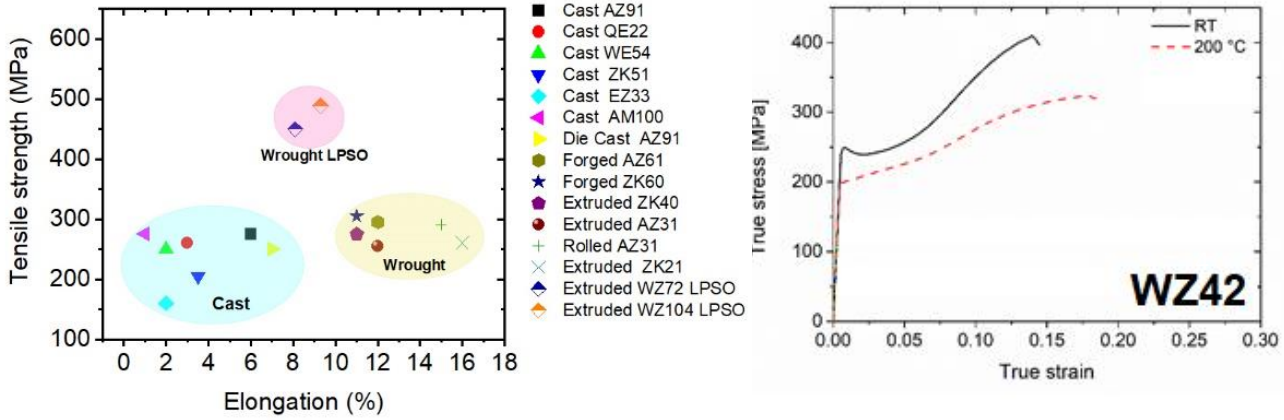




Improvement of mechanical and physical properties

E. Abe et al., Philos. Mag. Lett. 91 (2011) 690.



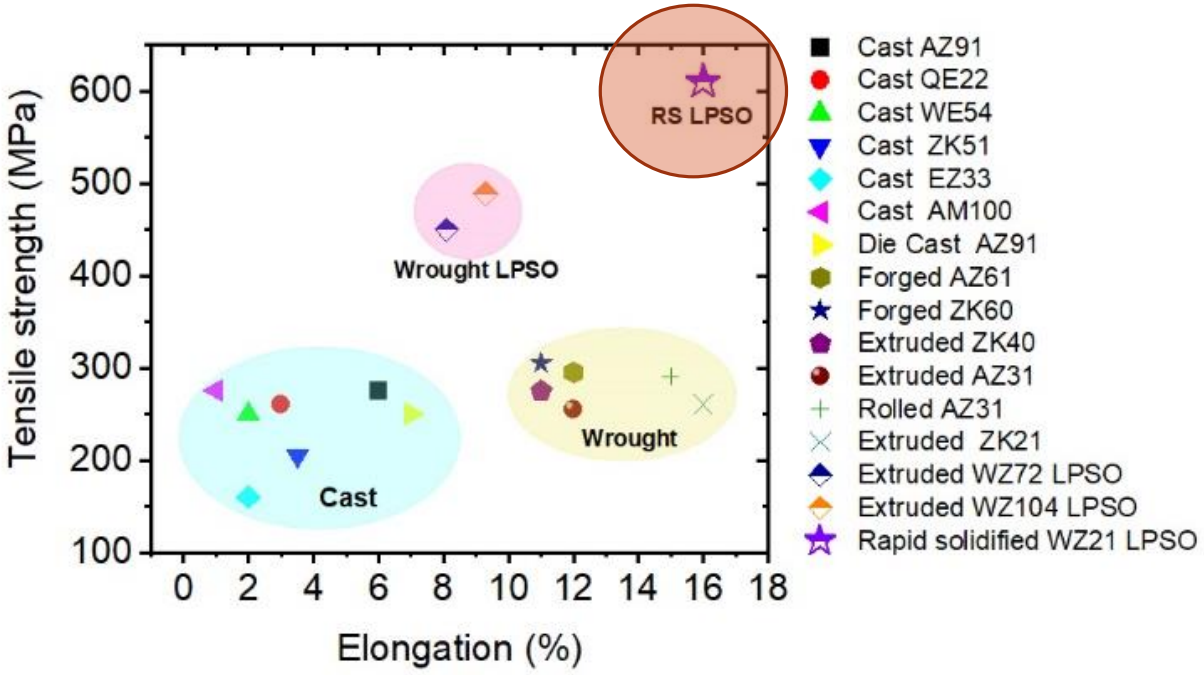


Motivation – engineering applications

Possible solution - improvement

Rapidly solidified (RS) Mg-Rare Earth-Transition Metals alloys

- The better properties can be reached by reduced amount of RE ;
- High ignition temperature (RS Mg > 1050 °C steel - 900 °C, Al – 1000 °C



PROCESS

Alloy production

↓

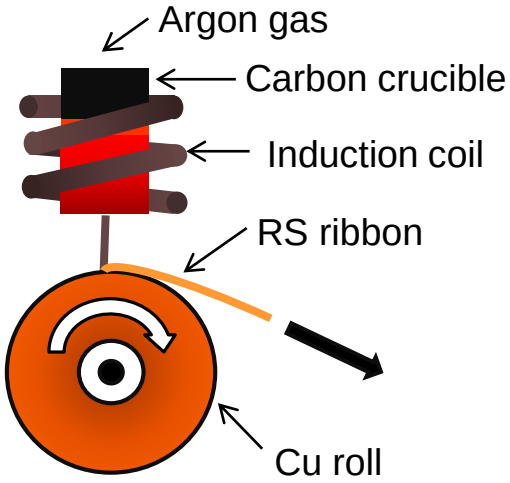
Rapidly solidified ribbon

↓

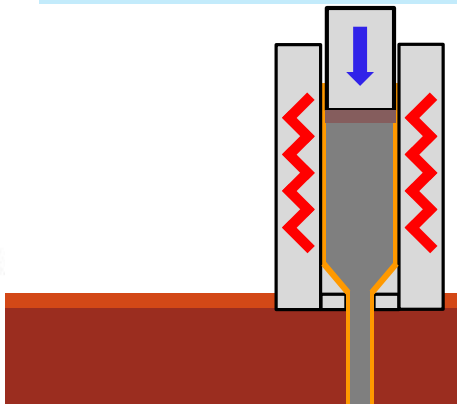
Preparation of billet for solidification molding

↓

Extrusion processing



Single-Roller Melt Spinning



Motivation – Mg for medical use

Conventional magnesium alloys

Advantages

- Non-toxicity
- Elastic modulus similar to that of bone
- Biodegrability

Disadvantages

- Not sufficient mech. prop.
- Non-controllable corrosion
- Rapid H_2 release
- Current applications are limited to small parts (screws, stents etc.)

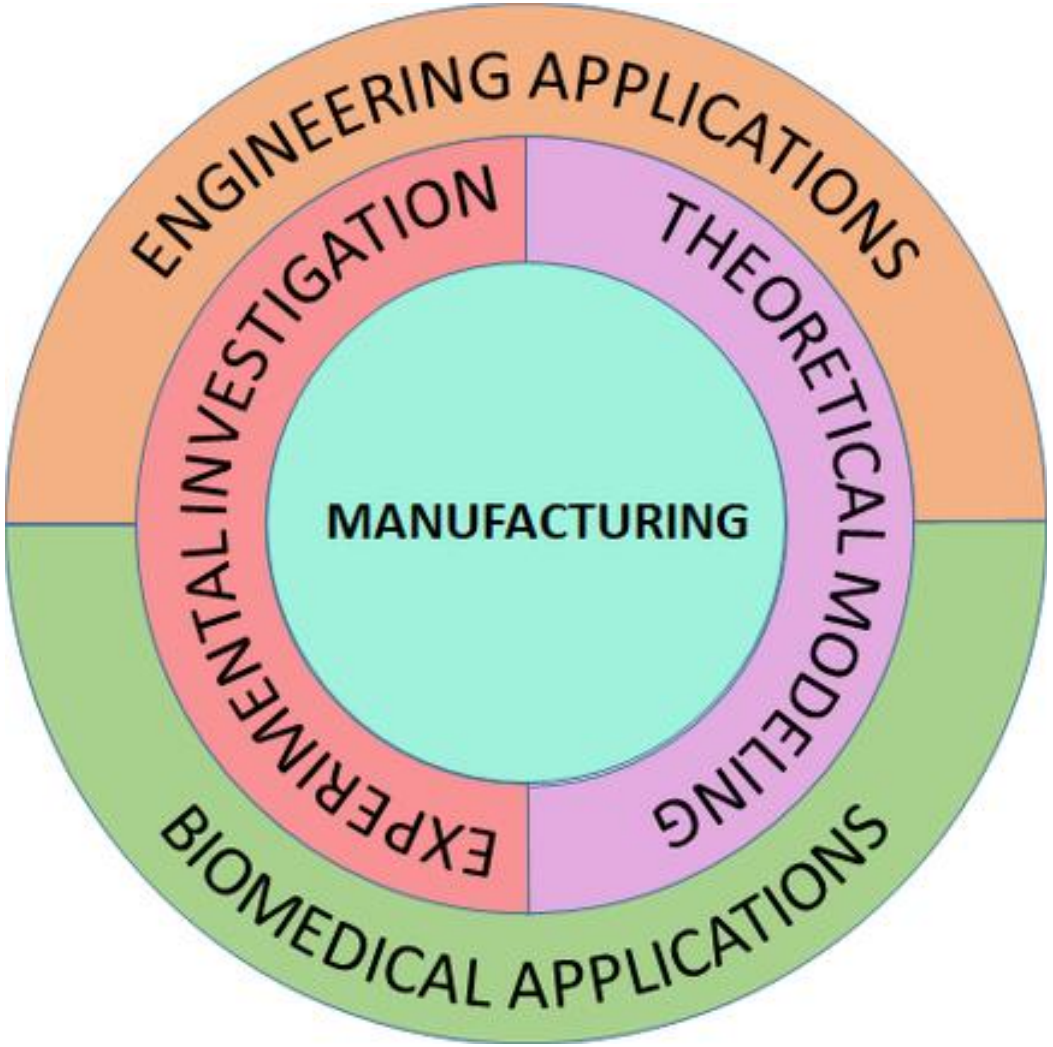
Yao et al., Biomaterials 2015

Windhagen et al. BioMed Eng. (2013)

current development of bioimplants requires **complex scientific-based research of high-strength Mg alloys** as potential material for biomedical application.

By proper choice of alloying content, processing method and coating both the mechanical and corrosion properties can be tailored

Responsibilities



Japan	**KU**
• production of material • computational materials science	
Czech Republic	**CUNI**
• detailed microstructure analysis • advanced *in-situ* testing	
Hungary	**ELTE**
• defect structure analysis • thermal stability	
Poland	**WUT**
• corrosion resistance investigation • biocompatibility testing	
Slovakia	**IMR**
• coating deposition optimization • mechanical and tribological properties of protective coatings	

Main objectives of the project

Research and development of Mg-Rare Earths (RE)-Transition Metals (TM)-based alloys

- High temperature applications
  → preservation of mechanical properties above 200 °C
  → improvement of refractory properties

- Applicability in the human body
  → improvement of corrosion properties and biocompatibility

- Tailoring of properties for the particular applications (biomedical, engineering) by application of protective layer