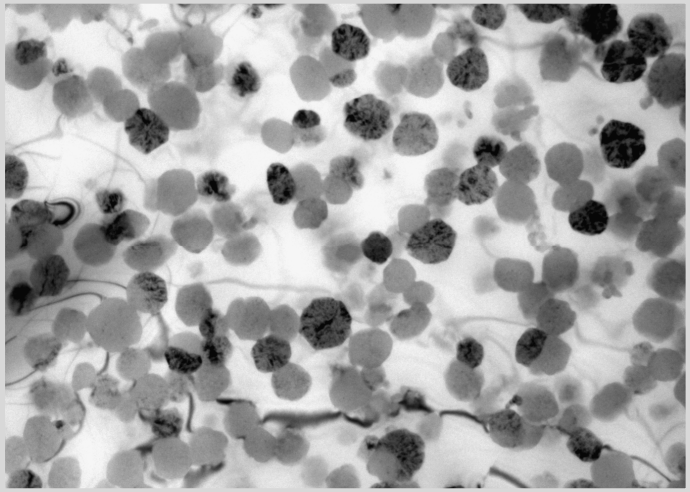
HUMAN CAPITAL
NATIONAL COHESION STRATEGY

INSTITUTE OF METALLURGY
AND MATERIALS SCIENCE
Polish Academy of Sciences

EUROPEAN
UNION

Aluminium base alloys strengthened by quasicrystalline particles

Presentation of the results obtained so far



Interdisciplinary PhD Studies in Materials Engineering with English as the language of instruction
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Project is co-financed by European Union within European Social Fund

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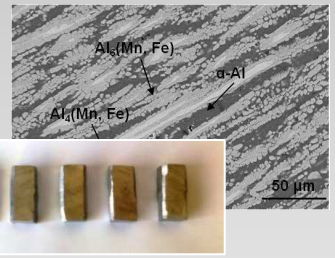
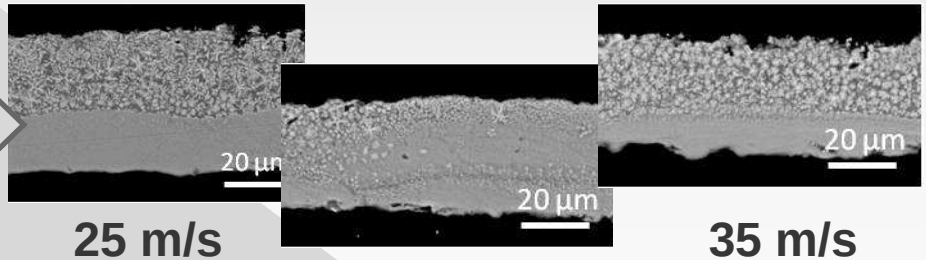
After review of scientific papers an alloy based on Al-Mn-Fe system was chosen for investigation

Preparation of the Al-Mn-Fe alloy by conventional casting



Melt spun ribbons preparation at various conditions (different wheel speeds)



25 m/s **30 m/s** **35 m/s**

Samples investigation: SEM, TEM, DSC, XRD, microhardness measurements, tensile tests

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Full characterization of the Al-Mn-Fe ternary alloy

Microstructure characterization

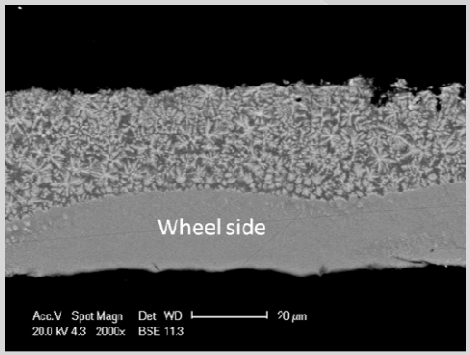
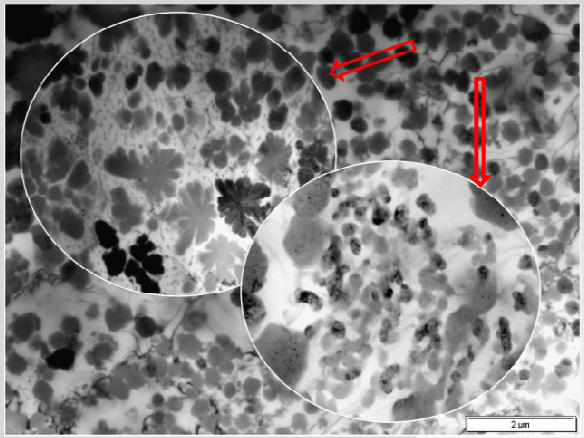
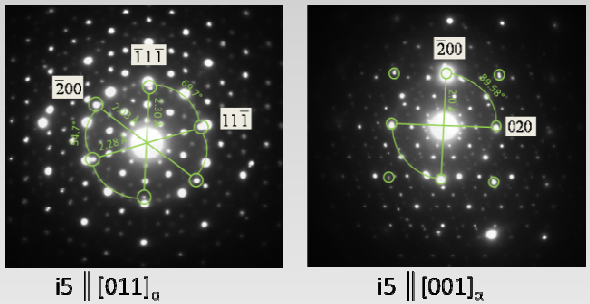


Image of the ribbon cross-section made by SEM revealing formation of two typical zones within the ribbon, with fine particles at the wheel side and dendrites at the air side



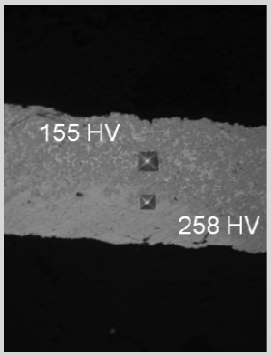
TEM – bright field image of ribbon microstructure



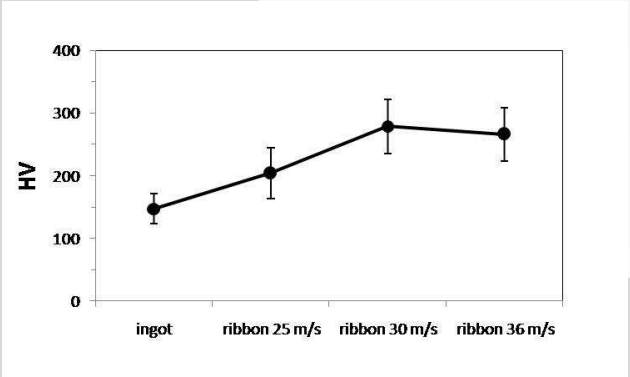
$i5 \parallel [011]_{\alpha}$ $i5 \parallel [001]_{\alpha}$

Crystallographic relationships between matrix and strengthening phase

Microhardness measurements

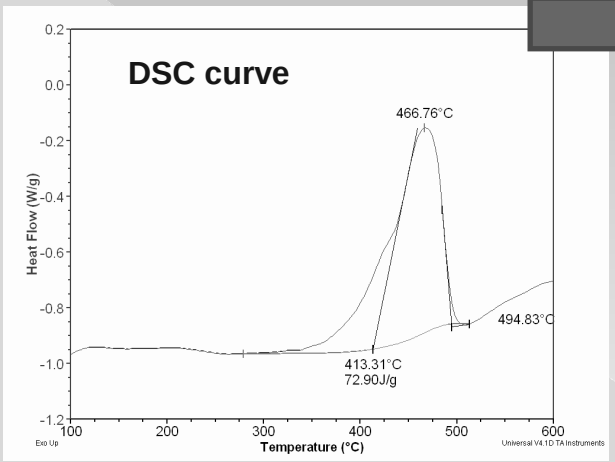


Influence of inhomogeneity of ribbons microstructure on microhardness values

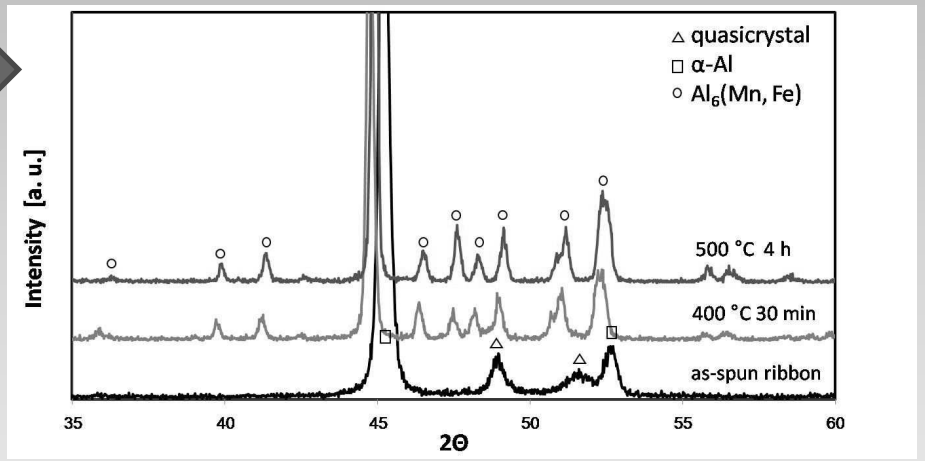


Changes of microhardness values for ribbons produced at different wheel speeds

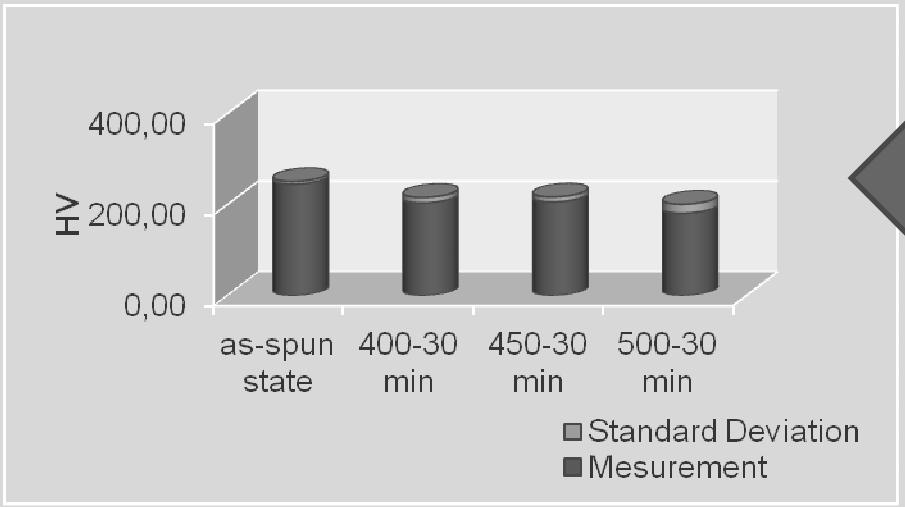
Thermal stability of the Al-Mn-Fe ternary alloy



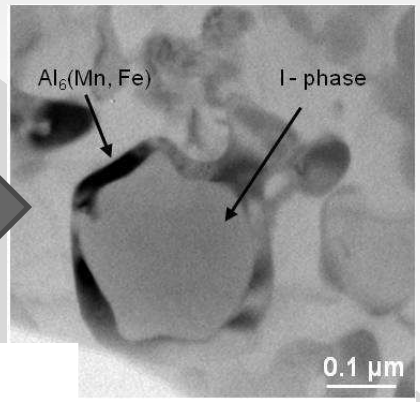
Change of sample phase composition after annealing analyzed using XRD



Changes of mechanical properties after annealing at different temperatures



Change of microstructure after annealing analyzed using XRD and TEM



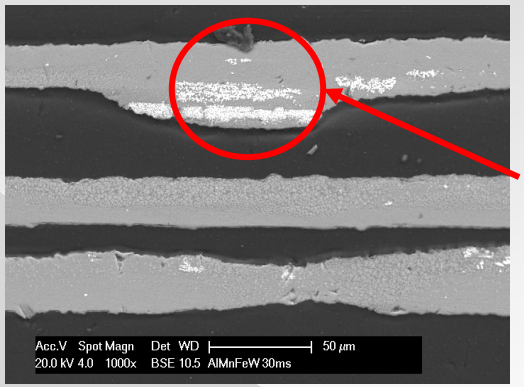
Decomposition of quasicrystalline particle into stable crystalline phase – bright field image TEM

Other compositions:

(Both cast ingots and melt spun ribbons)

AlMnFeZr
AlMnFeCr
AlMnFeV
AlMnFeTi
AlMnFeMo
AlMnFeW

Fully characterized



Problem with unmelted particles !

AlMnFeCu
AlMnFeSi

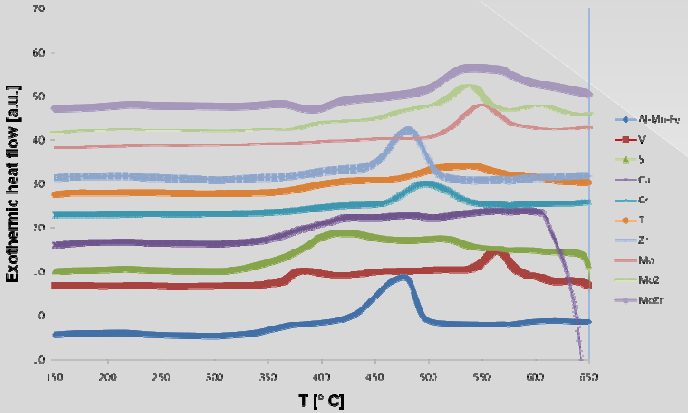
Partially characterized

AlMnFeZrMo
AlMnFeMo

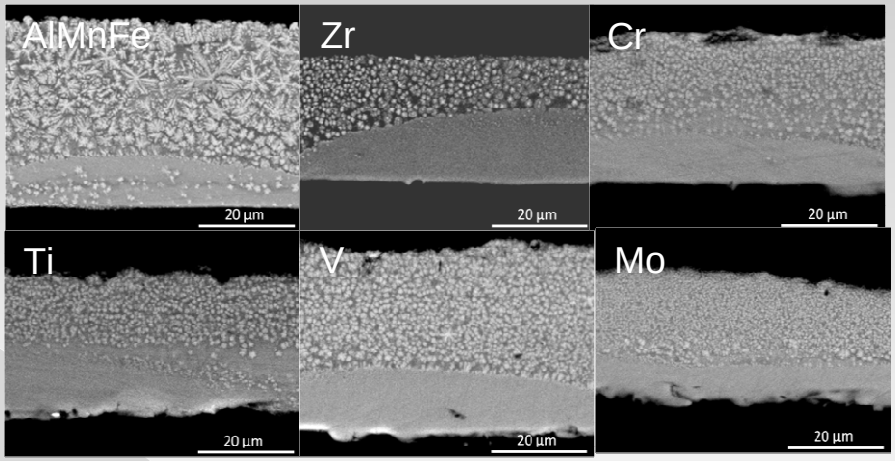
Partially characterized

Examples of obtained results

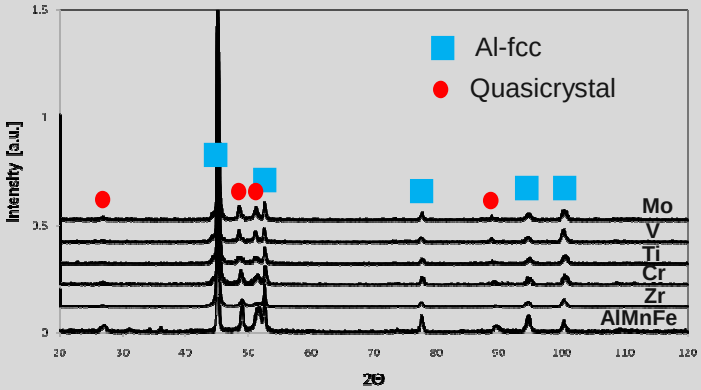
DSC – measurements of alloys thermal stability



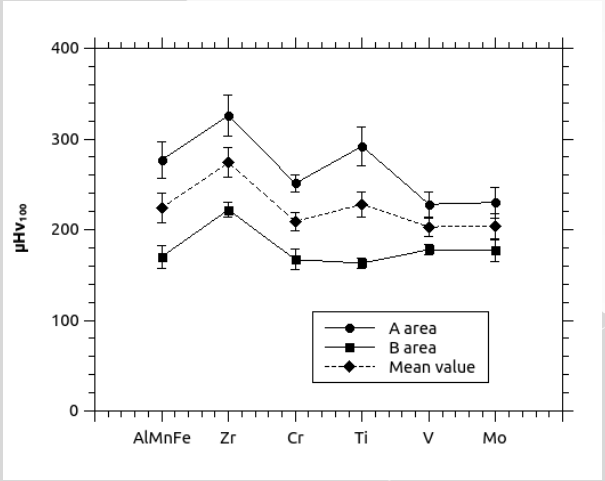
SEM – microstructure observation



XRD – phase composition analysis



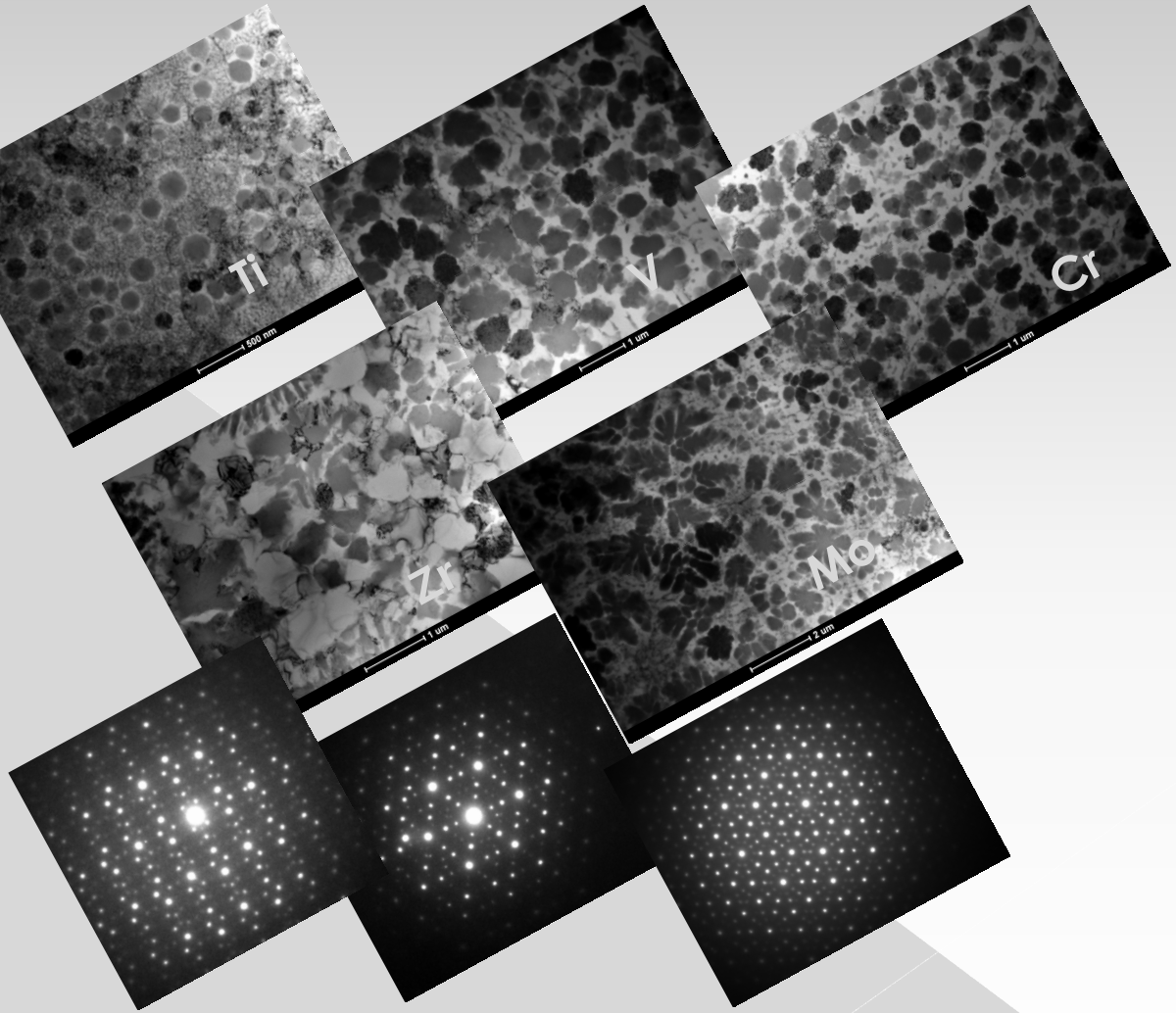
Determination of mechanical properties



Examples of results

Detailed microstructure studies using TEM revealed presence of the quasicrystalline phase of icosahedral type (identify based on SADP) with different morphology (from spherical particles to dendrites and eutectic-like structure) and size from several μm to hundred of nm

Bright field images showing melt spun ribbons microstructure



SADP revealing 2-, 3- and 5-fold symmetry typical for the icosahedral quasicrystals

Preliminary conclusions based on obtained results

Best mechanical properties – alloy with Zr and Ti addition

Best thermal stability – alloy with Mo addition

Detailed studies of these two alloys:

AlMnFeZr

AlMnFeMo

AlMnFeZrMo
AlMnFeMo

Design of new alloys based on obtained results

Presented results

Plans for future

Some other composition (W, Hf and Y addition, alloys with higher content of Al in the aim to reduce samples brittleness) and their characterization

Bulk specimen from optimized composition – by pulverization of ribbons (milling) and compaction via pressing or extrusion

Characterization of microstructure, mechanical properties (not only hardness but also compression tests), thermal stability vs. deterioration of properties