Microstructural conditions of the improvement of properties of Mg construction alloys

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Microstructural conditions of the improvement of properties of Mg construction alloys

Poor formability and ductility at ambient temperature:

➢ Hexagonal close-packed crystal structure results in insufficient independent slip systems

Softening at higher temperatures:

➢ During warm and hot working several non-basal slip systems operate in addition to the basal slip plane, which leads to increase of the plastic workability

➢ Conventional methods of work hardening require elevated temperatures. Hot working involves dynamic recrystallization decreasing the desireable microstructural forming effects.

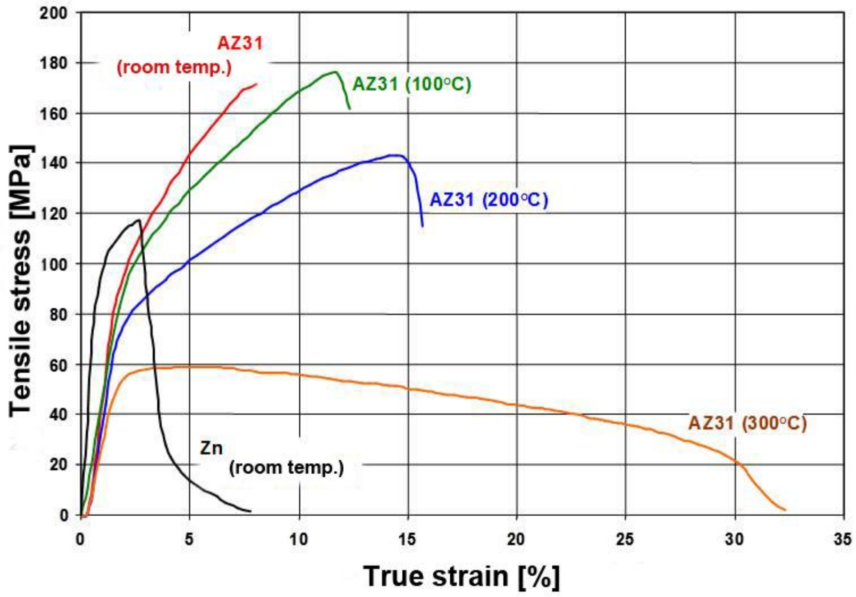


Fig 1. Nominal tensile stress-strain curves for Mg-AZ31 alloy samples tested at various temperatures (room to 300°C with rate of 16 $\cdot 10^{-3}$ s^{-1} (Bonarski J, Pospiech J, 2010)

Microstructural conditions of the improvement of properties of Mg construction alloys

- Thermomechanical strengthening
- Effect of ultrasounds
- Mg – P phase diagram

Effect of ultrasounds

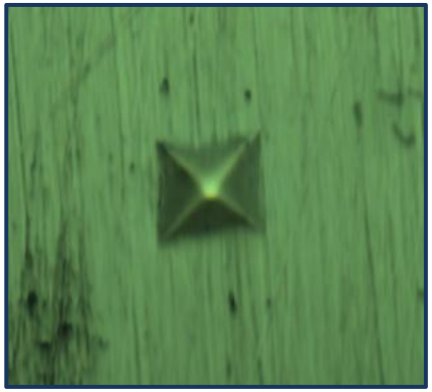
- Attempts to use ultrasounds during tensile test in order to increase plastic deformation were unsuccesful
- In the new approach we focused on modification of samples structure by ultrasonic treatment
- Wrougth AZ31 and AZ91 samples were put into dish filled with diffrent types of suspensions

- The energy of ultrasonic waves introduced rapid changes in the pressure of the liquid in which the samples were immersed

Effect of ultrasounds on microstructure and hardness

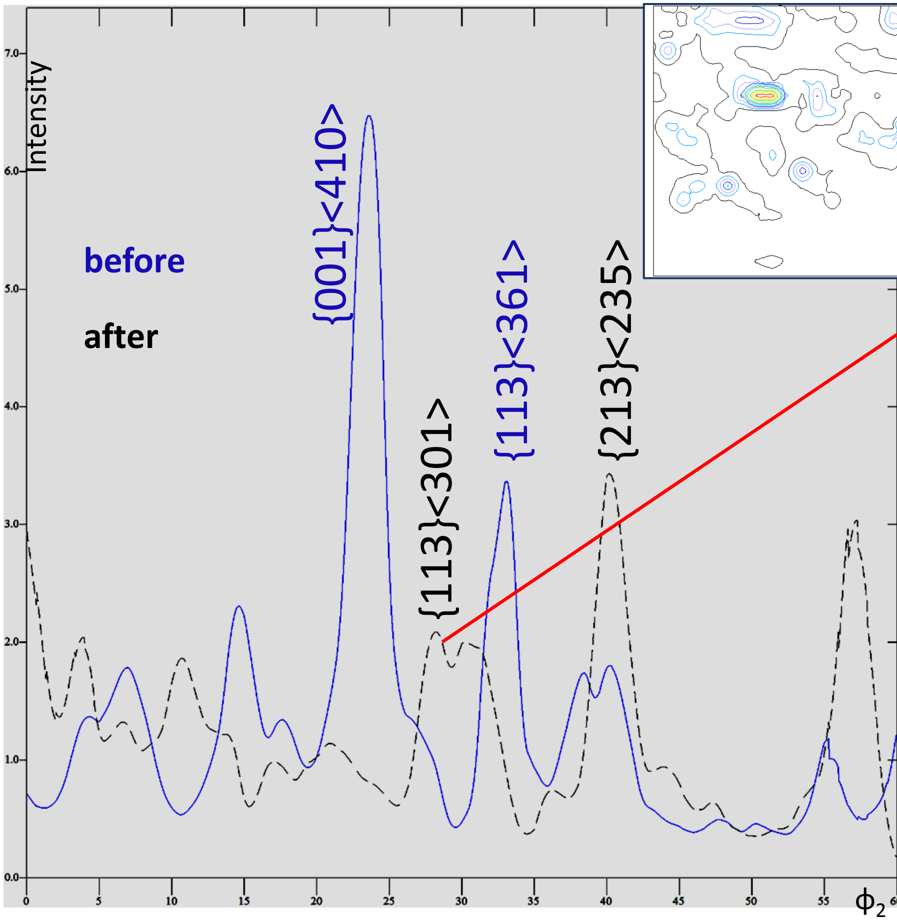
Austenite sheet, 50x

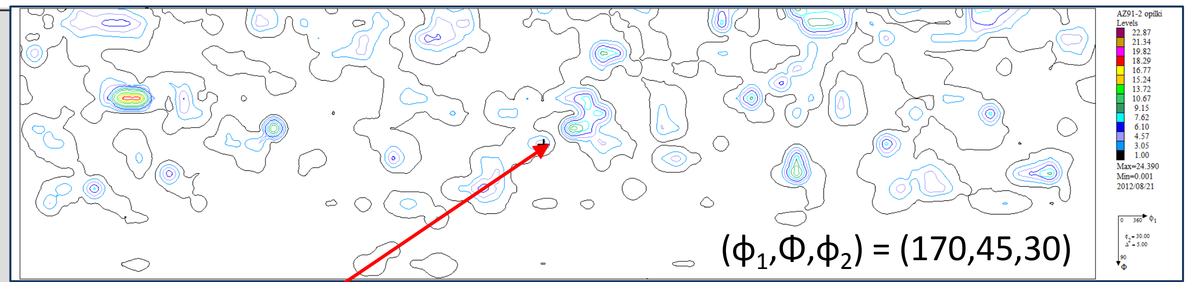
Austenite sheet after ultrasonic treatment, 50x



- No changes in microstructure were observed
- Microhardness of AZ91: mean 119 HV (σ= 22.803)
- Microhardness of AZ91 after ultrasonic treatment: mean 117 HV (σ=12.056)

Effect of ultrasounds on texture

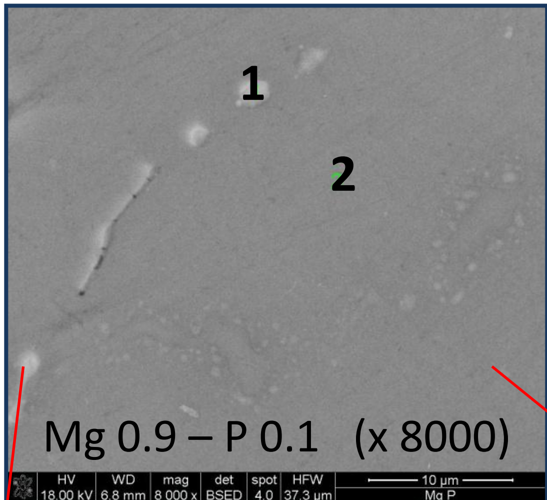




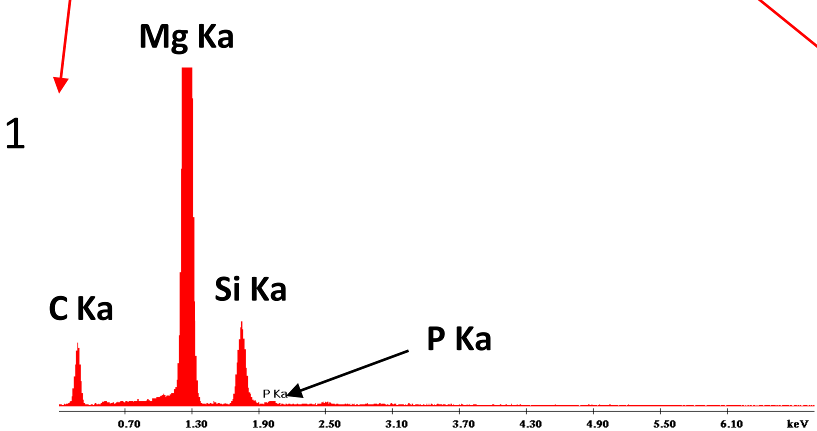
AZ91 ultrasonic treated in couplant of iron filings

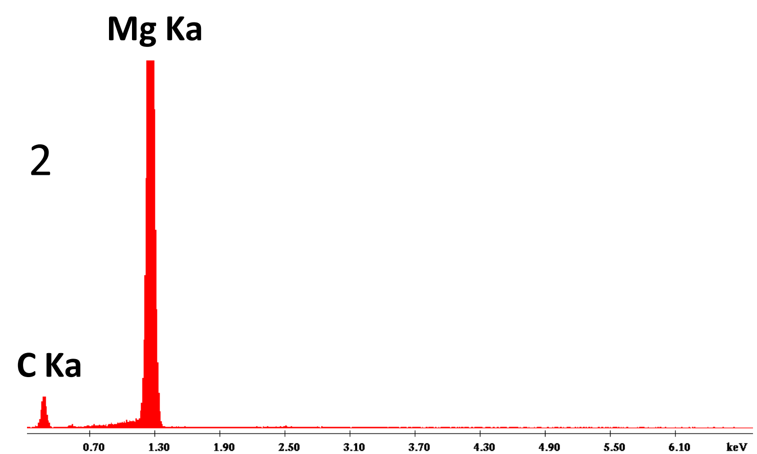
- The texture of the sample was modified by treatment in Fe fillings
- Skeleton lines showed changes in crystallites directons and orientations
- Orientation {113}<361> transformed into {113}<361>
- Orientation {001}<410> vanished

Mg – P system

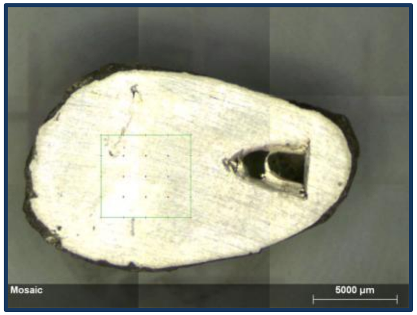


- Mg tubes filled with red phosphorus (10 w%) were melted in crucible in protective atmosphere
- Sample examination by SEM revealed white precipitations of Si in homogenous phase of Mg
- Also trace amount of P inside white precipitations was found

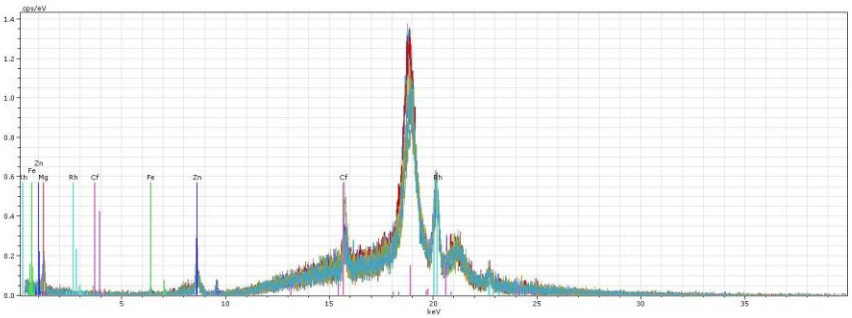


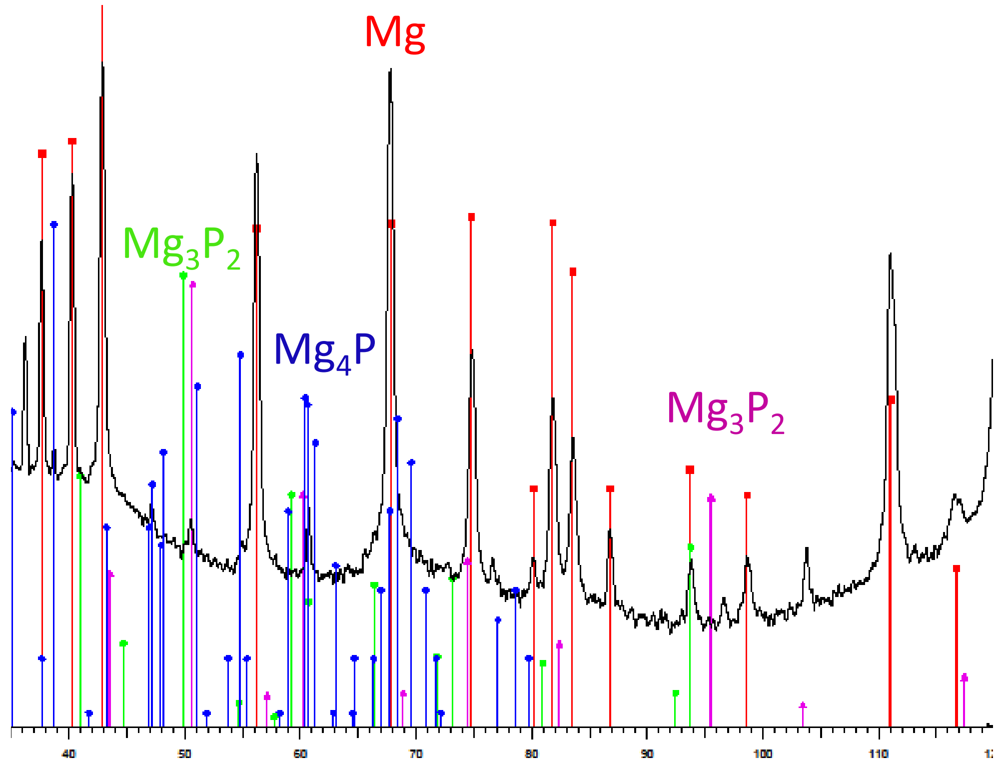


Mg – P system



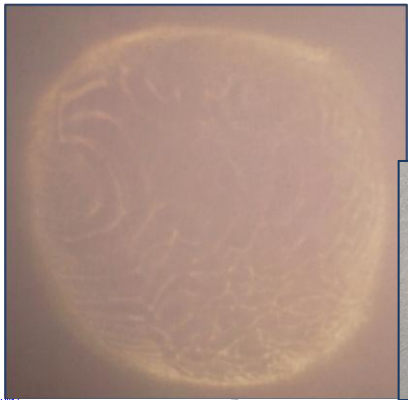
	[wt.%]	[at.%]	(1 Sigma), %
Mg 12 K-series	99.97	99.99	0.74
Fe 26 K-series	0.01	0.00	0.00



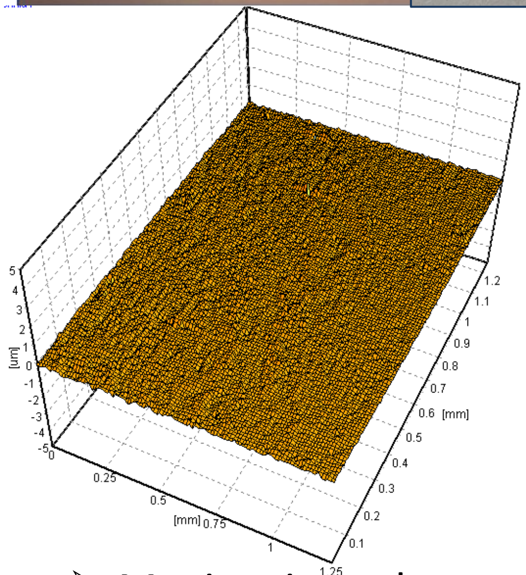


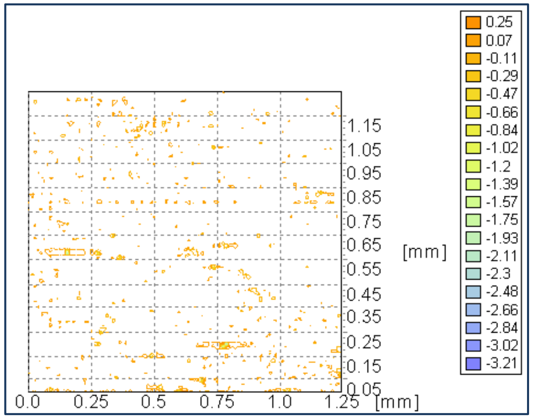
- ➢ Spectral analysis proved that solubility of P in Mg is negligible
- ➢ Phase analysis of Mg10P samples does not confirm presence of magnesium-phosphorus phases

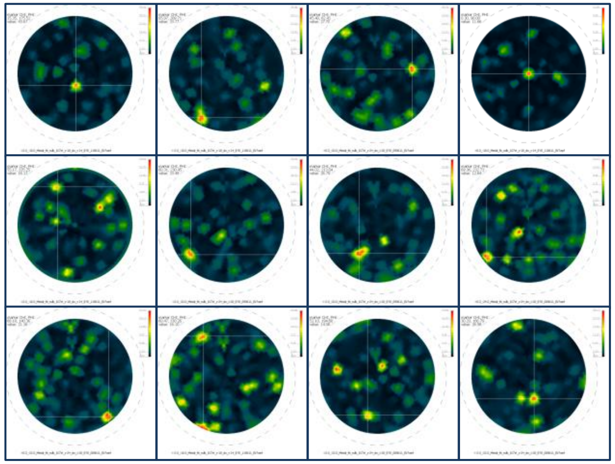
Chinese Mirror



- First accepted scientific explanation was proposed by **Sir William Bragg** in 1933. He assumed that imperceptible irregularities on the front cause the image in the reflection.







- Magic mirror does not work that way, which was confirmed by analysis of topographic image

- Neither is the image hidden in texture, we expect that it depends on changes in electron density introduced in manufacturing process

Results:

- Significant changes in texture were achieved for the sample modified by treatment in Fe fillings
- Ultrasonic treatment had no effect on mechanical properties and microstructure
- In spite of several attempts of alloying magnesium with phosphorus, only trace amount of phosphorus was found in solid solution
- Metal sample reflectivity was changed by introducing local microstructural defects, which affected electron density

Plans for future: Thermomechanical strengthening

- In spite of a few successful attempts at forming in elevated temperature described in the literature, cast alloys still do not have sufficient mechanical properties

- For this reason diecasting and pressing of Mg alloys is not applicable to advanced constructions in aircraft and automotive industry

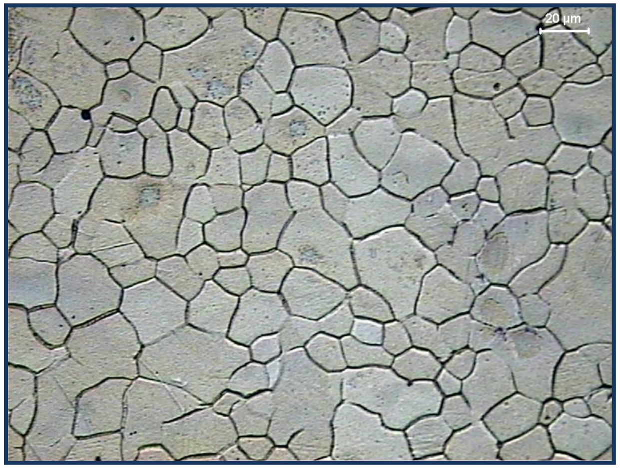
- Porosity occurs in Mg alloys products manufactured by commonly used cast methods

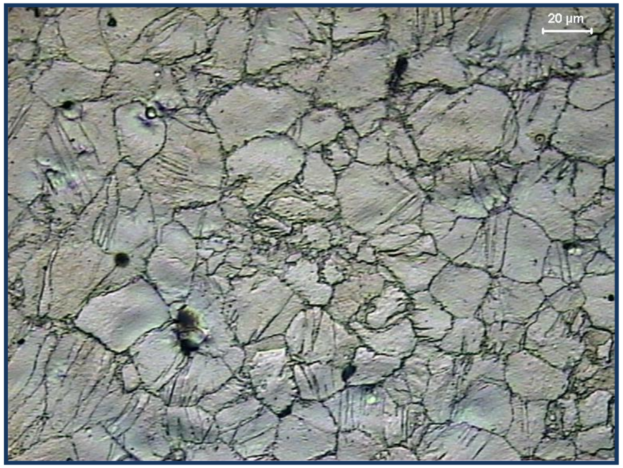
Mg-AZ91 hot extruded tube. The material discontinuities, microstructural defects (porosity, leakage) have not been eliminated due to lack of plastic deformation

Thermomechanical strengthening of Mg alloys

- First tests for Mg AZ 31 alloy pointed to the possibility of structural strengthening without loss of ductility

- AZ31 alloy's hardness has been improved by 30% (from 48 HV to 63 HV after treatment at fixed conditions), with sufficient ductility and beneficial microstructure preserved





Microstructure of AZ31 alloy after hot extrusion and thermomechanical treatment leading to structural strengthening

Thank you for your attention