Magnesium

for transportation systems

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Mg for transportation systems

Frames for airplane seats

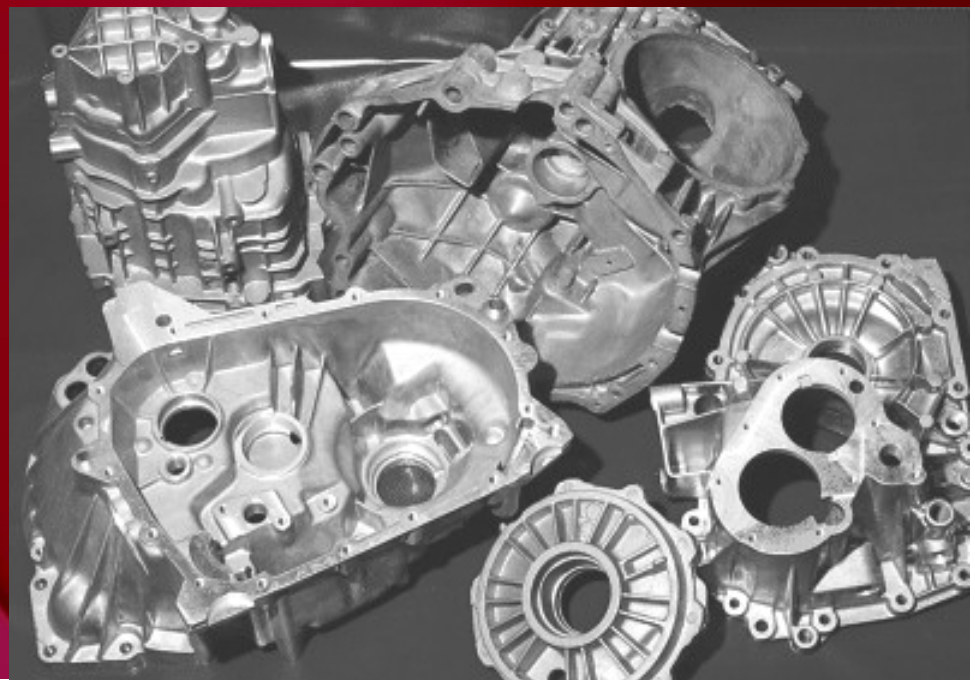
Airplane body planking

Car bodies

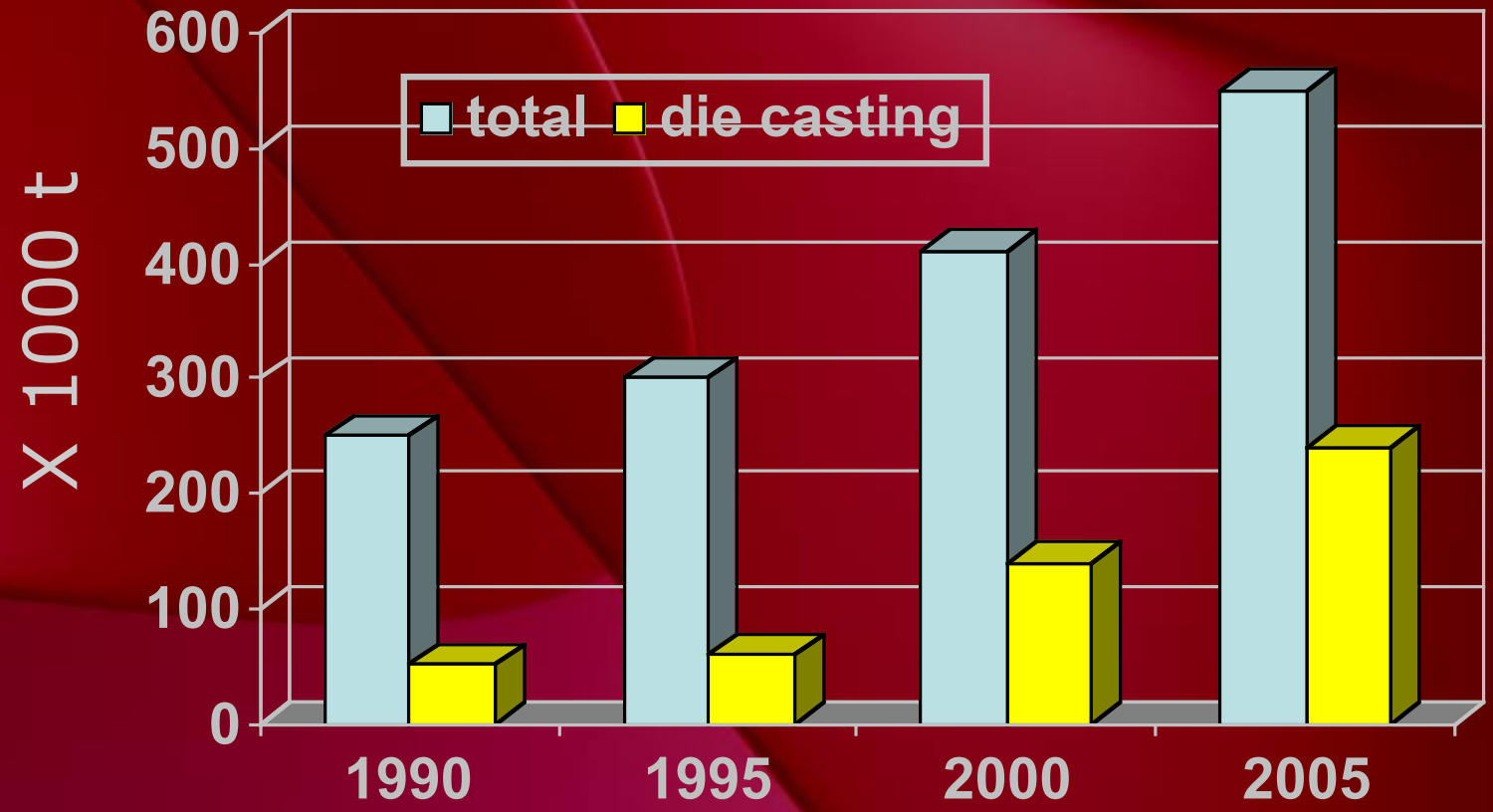
Source:
IG Farben, 1939

Racing bike; Opel 1922
Total weight 69 kg.
Piston and crankcase made of Mg.

VW beetle used 21 kg Mg of die castings in its gear box and engine block.
In the 1970's Mg demand reaches 42'000 tons



Mg consumption



Source:
Mg Alloy Corp., IMA

Mg consumption

Today: 3 kg average magnesium content in cars.
Target for 2005: 40 kg Mg per vehicle.

⇒ Requires tripling of existing capacity - from current 420 tpa to over 1.5 million tpa.

Today:
Porsche 911 uses 52 kg Mg per vehicle.
Audi A2 uses 20 kg, *A4* and *A6* have about 14 kg.
VW Passat platform uses 14 kg Mg. In 2005 this platform will incorporate between 28 to 42 kg, projected at 2 million units per year.

Source:
Mg Alloy Corp., IMA

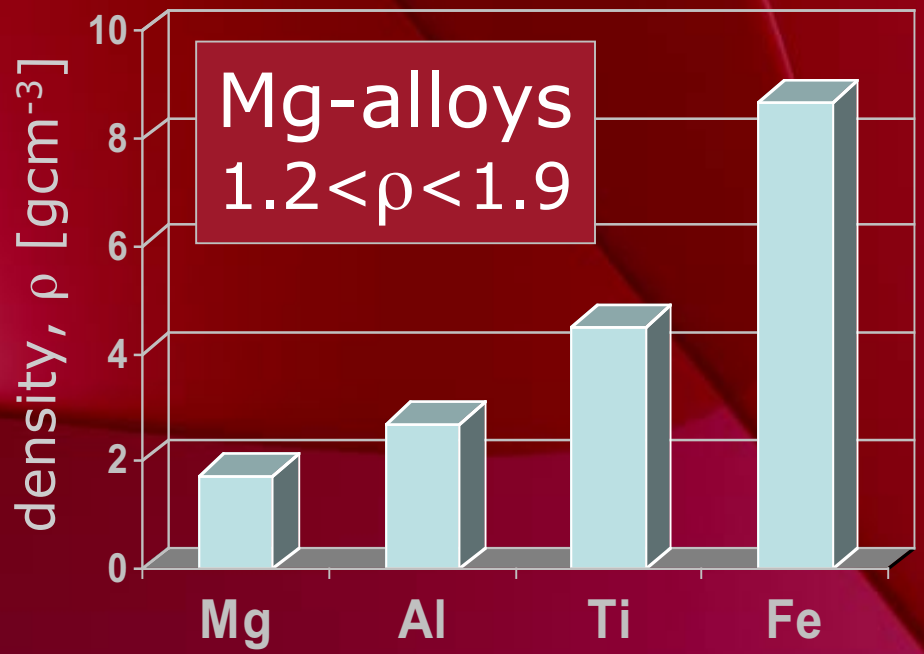
Auto companies buy into Mg projects

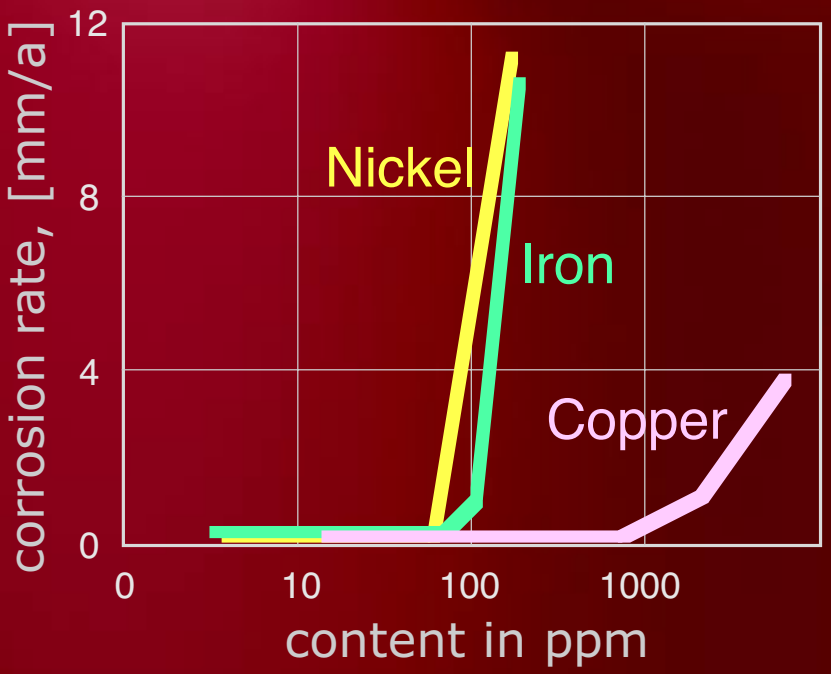
- *VW* has invested € 10^8 in Dead Sea Magnesium Ltd.
- *Ford* is participating in Australian Mg Corp by investing € 3.10^7 and placing a € $1,5.10^9$ order for Mg metal.
- *General Motors* and Norsk Hydro have announced a long -term supply agreement.
- *Toyota* is in joint venture with Noranda starting the € 5.10^8 Magnola (Serpentin debris) plant in Quebec.

Why the renaissance of Mg ?

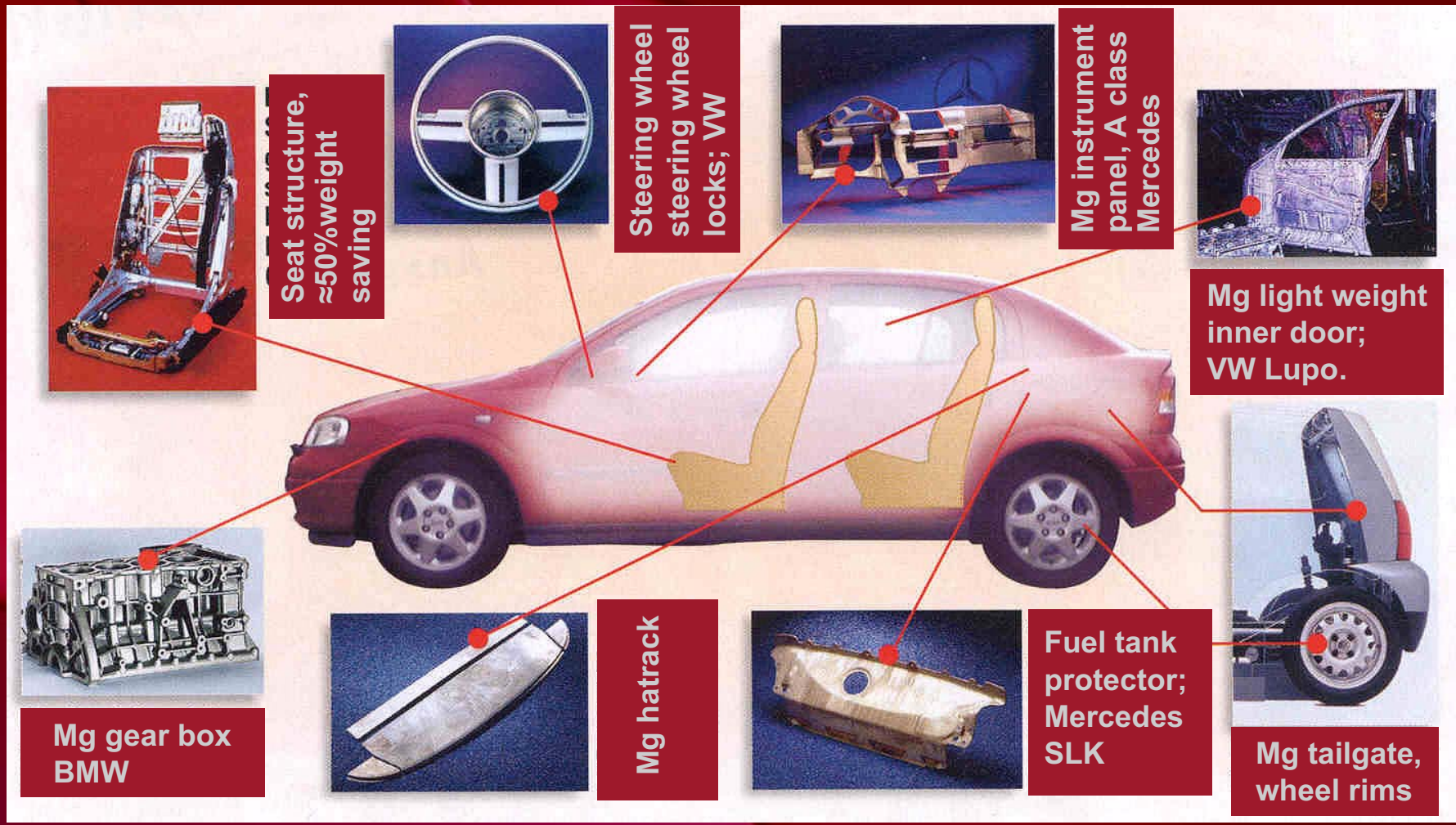
Lightweight construction of cars, railed vehicles, cabins, cable cars, roboting systems,..

Components for audio, video, computer, communication (AVCC) systems.



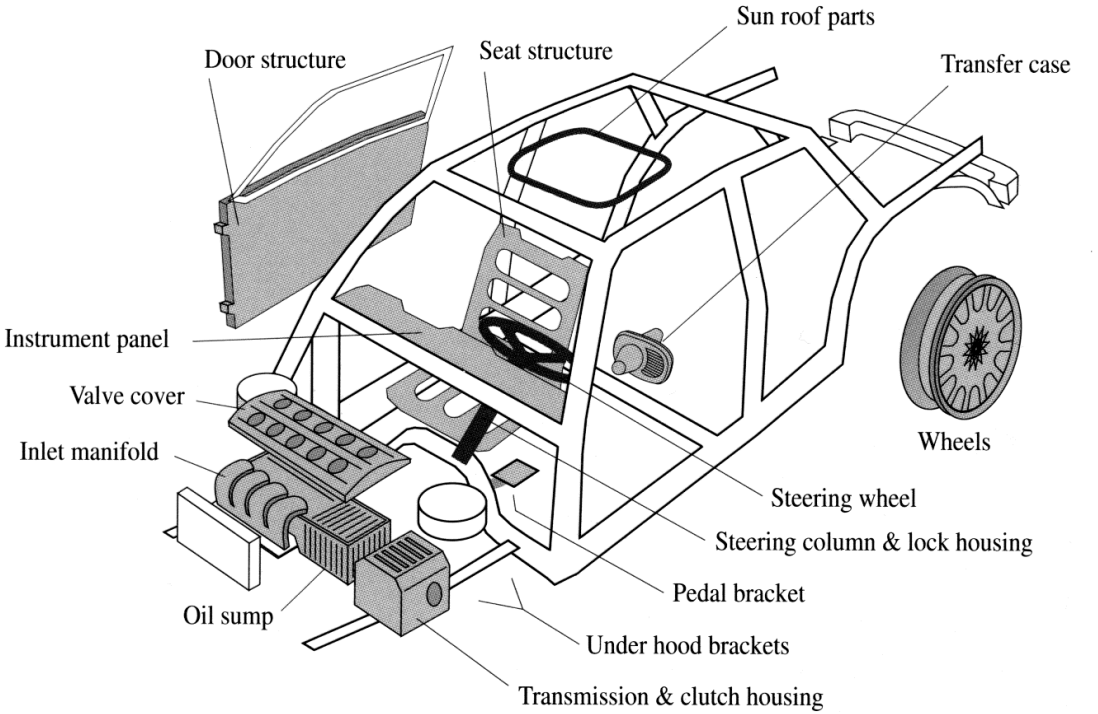


Mg automotive application today



Mg automotive application today

High Pressure Die Cast components for structural application at T <130°C where damage tolerance and pressure tightness is not required.



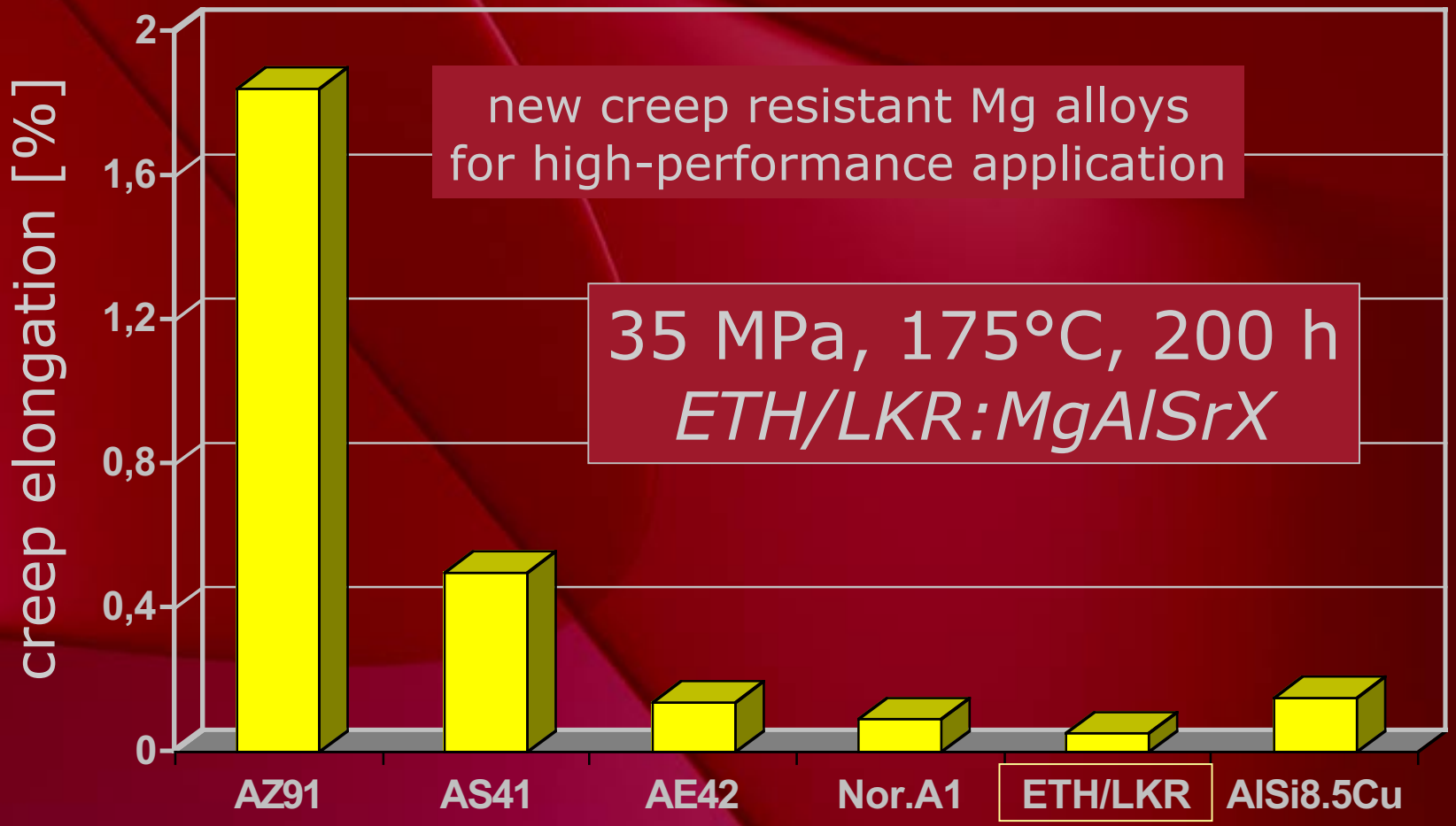
and tomorrow

Mg components for high-performance gear boxes, crankcases, engine blocks and hydraulic parts - require improved creep resistance, pressure tightness and thicker walls.

The solution:

New alloys and processes

Mg alloys for elevated temperature



Mg *physical and mechanical properties*

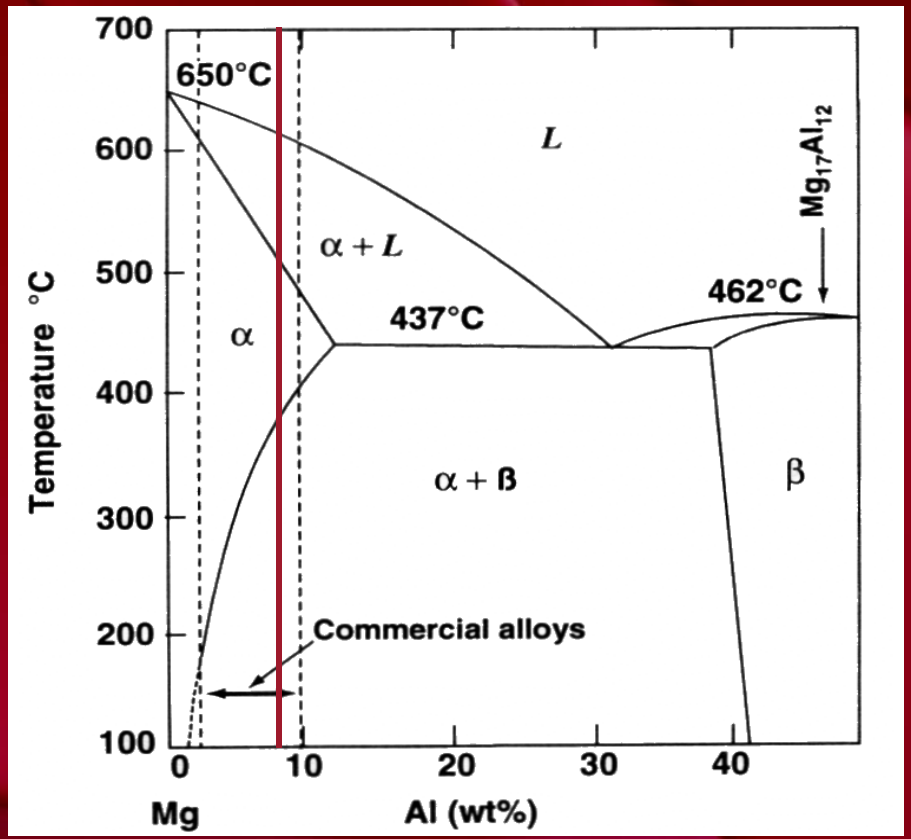
	ρ [g/cm^3]	E [GPa]	R_m [MPa]	α [$10^{-6}K^{-1}$]	λ [$Wm^{-1}K^{-1}$]
Fe	7.87	208	70 (3500)*	11.8	80
Ti	4.50	120	235 (1500)*	8.4	26
Al	2.70	62	45 (750)*	23.6	247
Mg	**1.74**	**44**	**55/90 (500)***	**26.1**	**157**

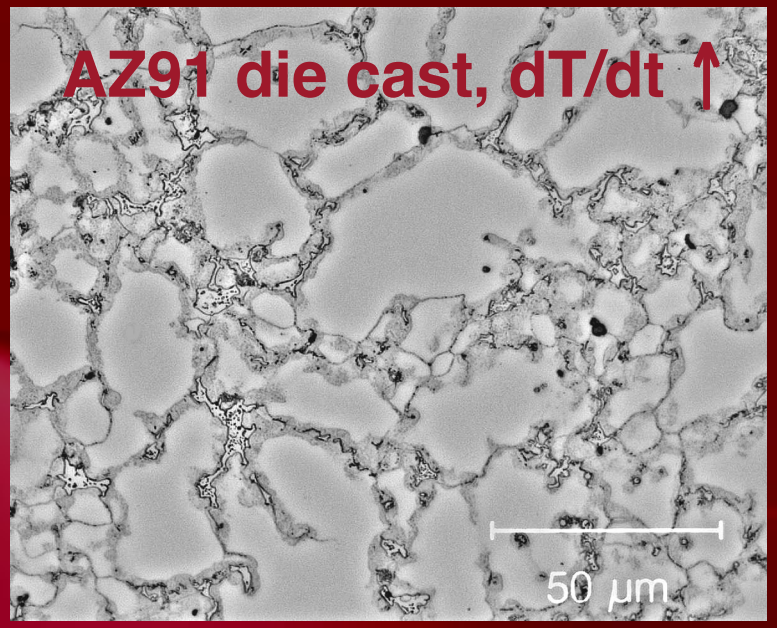
* **maximum strength**

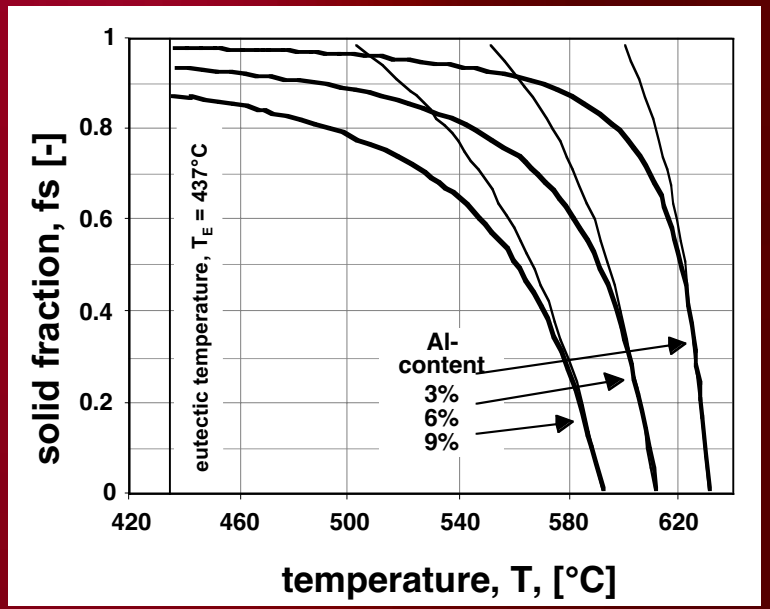
Problem: limited ductility (fracture toughness) due to

hexagonal crystal structure; solidification in non-equilibrium;
gas content in die cast components (heat treatment, welding ?)

non-equilibrium



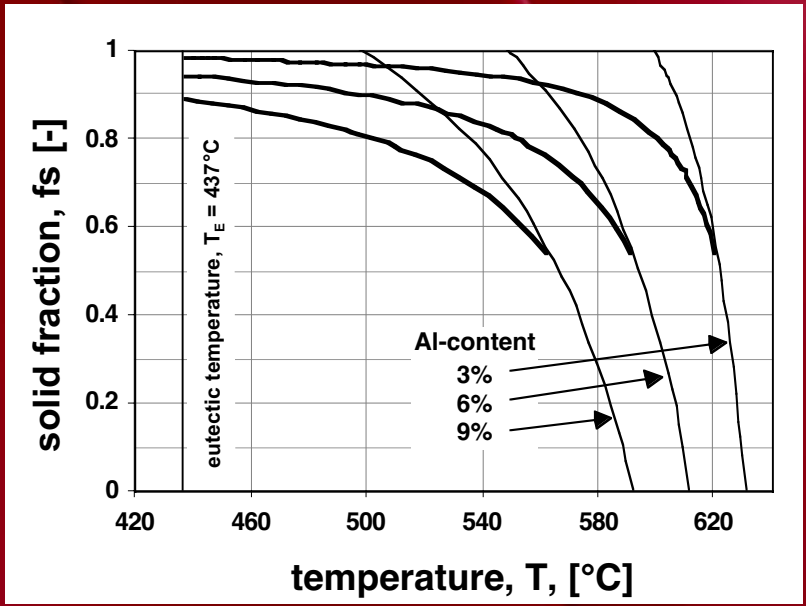


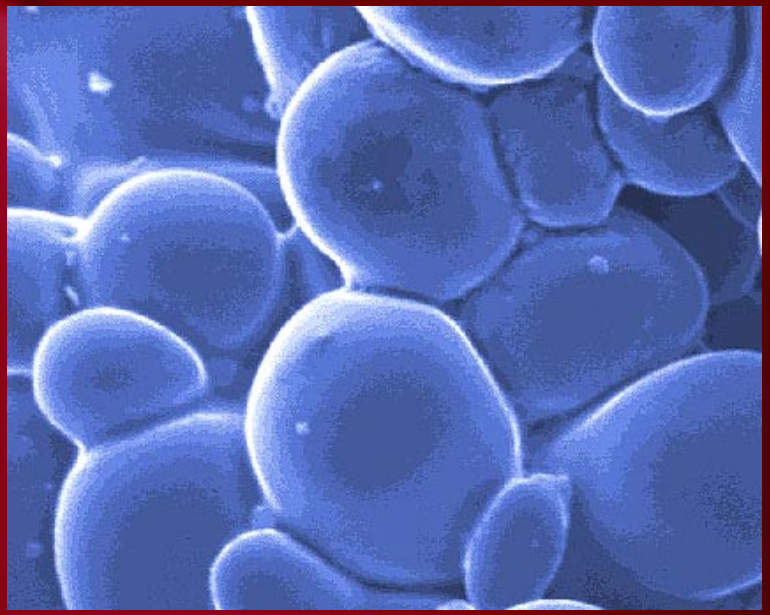


Non-equilibrium: formation of eutectic β-phase ($Mg_{17}Al_{12}$)

Semi-solid processing

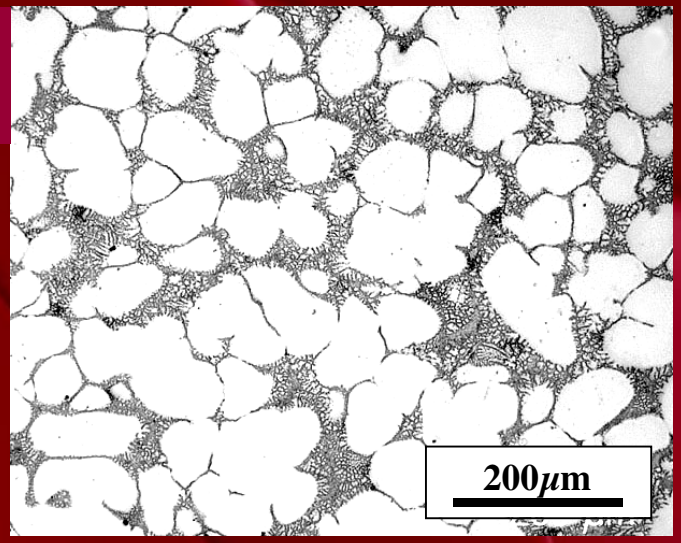
less brittle β-phase, no gas entrapment



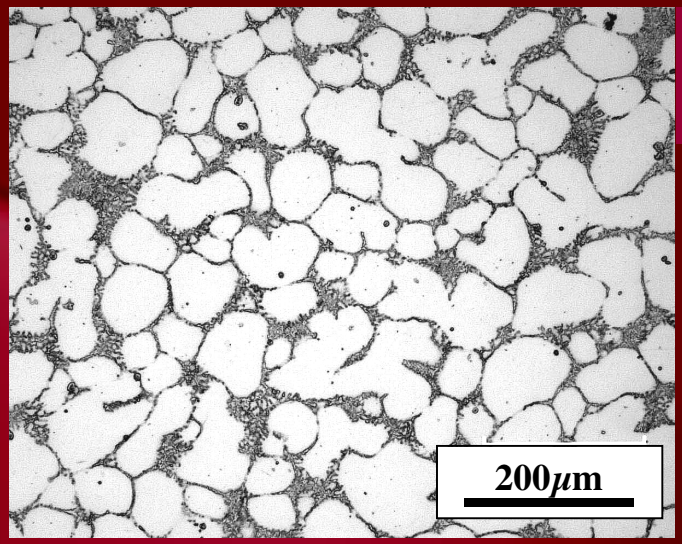


	AZ91	AZ71	AM60	AE42	AlSi7Mg
ΔT^{SL} [°C]	148	126	74	45	52
$\Delta T^{40/60}$ [°C]	**22**	**18**	**13**	**9**	**17**

AZ91



as cast



AZ71

as cast

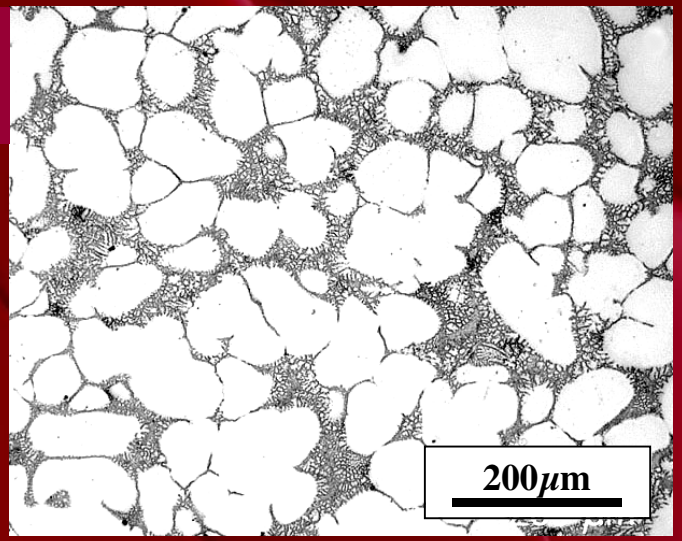
no gas entrapment

⇒ solution heat treatment possible

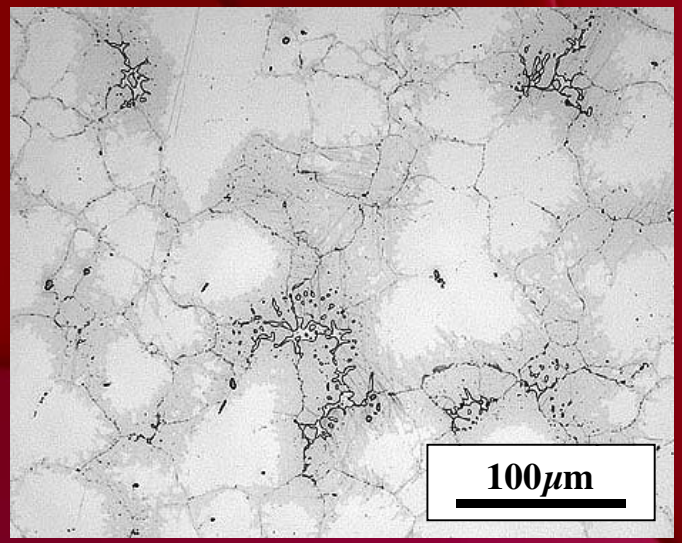
400°C/24h

AZ91

as cast

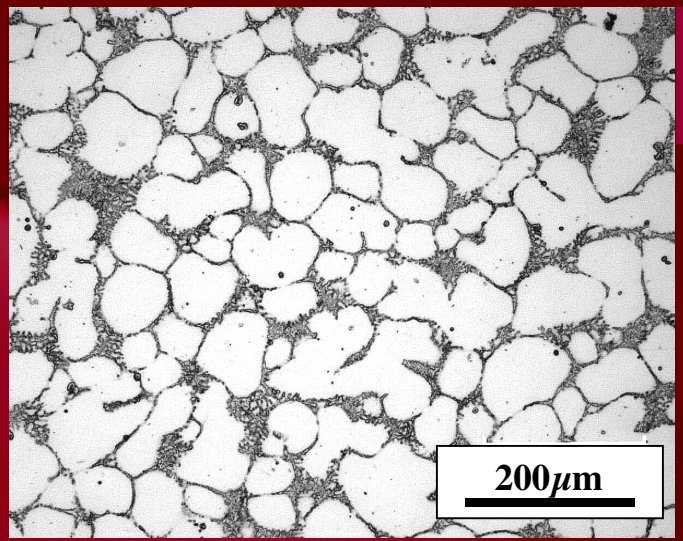


T4
400°C/24h



AZ71

as cast



T4
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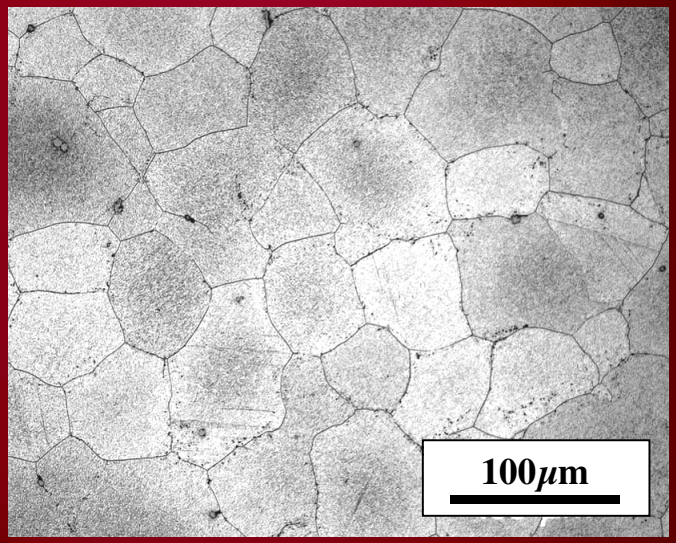
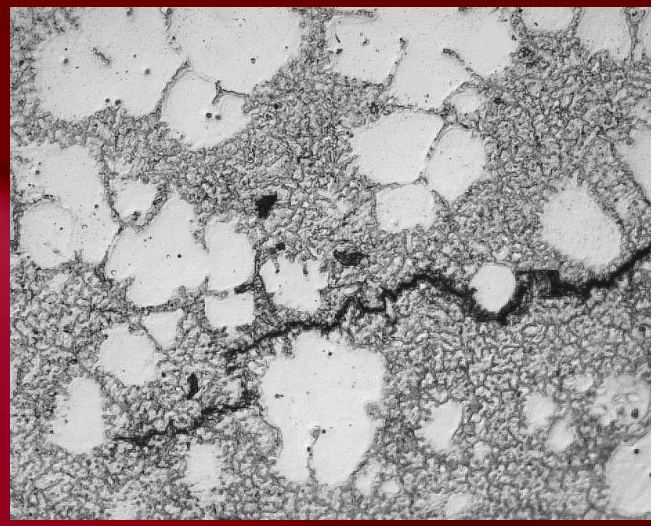
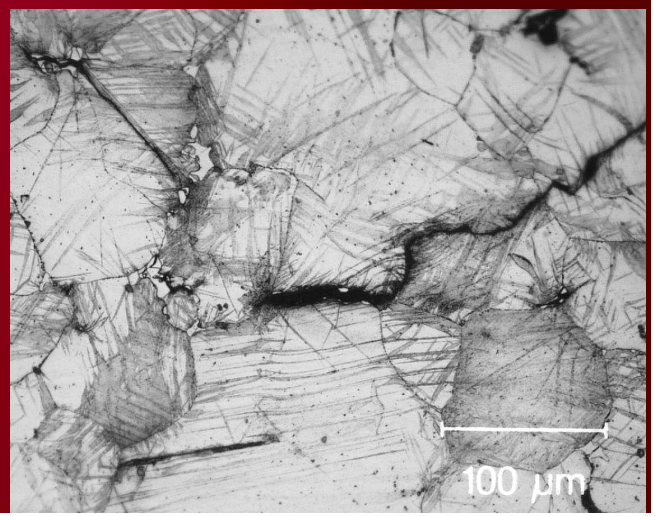


Mechanical properties

	NRC AZ71 as cast	NRC AZ71 T4	Die cast AZ91 as cast
$R_{p0.2}$ [MPa]	120±15	115±15	125±15
Rm [MPa]	195±8	270±25	215±30
A [%]	5.2±1.2	11.5±2.5	2±1.5
K_{JC} [MPa√m]	14±2	44±4	10.7





excellent ductility in T4 condition

Steering rod
alloy: AZ71, shot weight 1850 g

Outlook:

- NRC adapted AZ alloys
- Heat resistance AZ-X alloys
- Heat treatment optimization
- Implementation of Mg recycling

Mg in-house recycling