

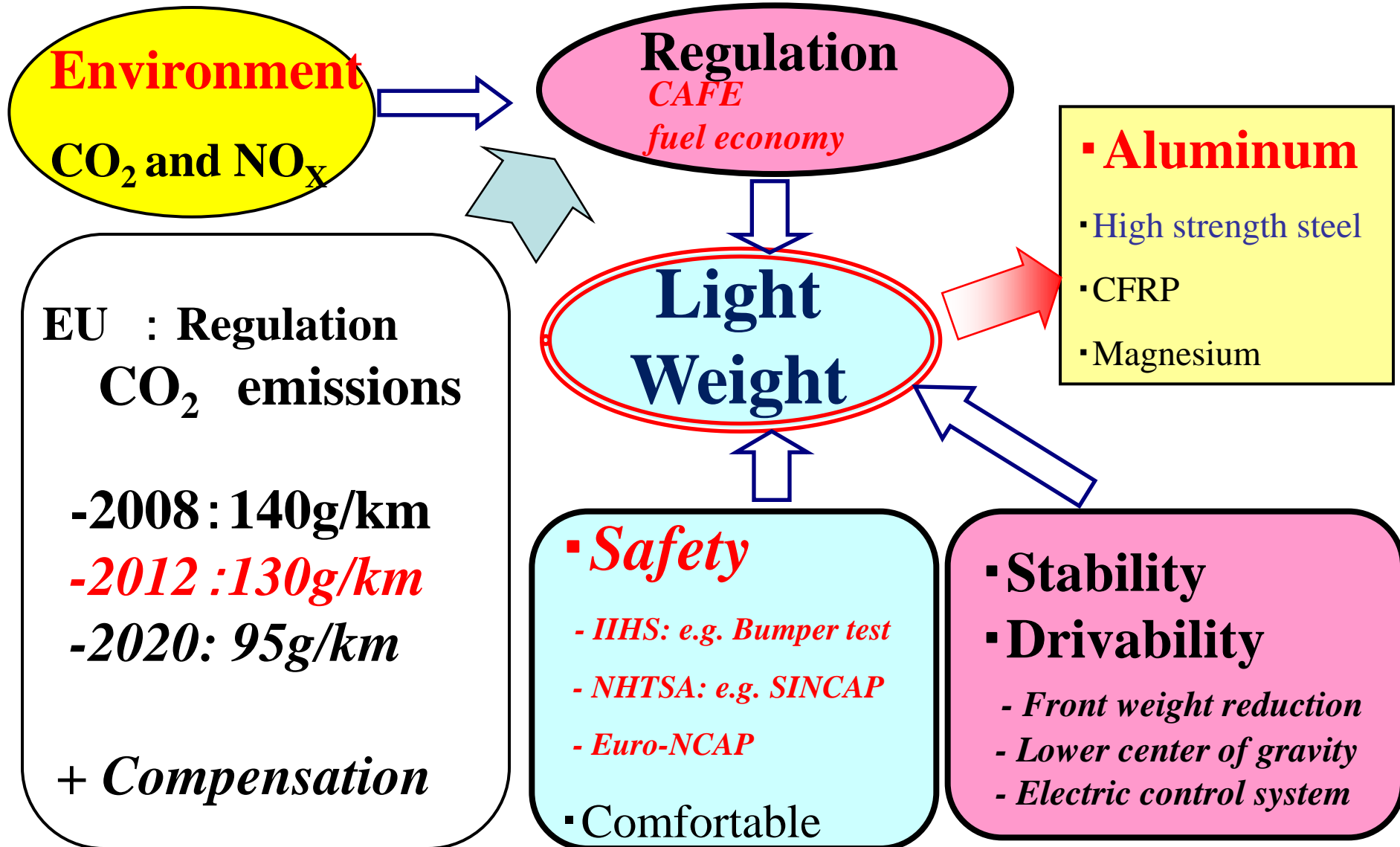
# Current Light-weighting technologies on Aluminum alloys for Automotive body structures

Dr. Tadashi Aiura  
KOBE STEEL, Ltd.

# Contents

- ◆ ***The background on light weighing requirements of automotive body structures***
- ◆ ***Light weighing technologies of Closure Panels by Aluminum Alloy***
  - Advantages of Aluminum on Closure panel applications
  - Effect of additive on high paint bake response of 6xxx alloy.
  - Forming & Joining technologies
- ◆ ***Prospects on aluminum alloy applications for light weight Automotive bodies in the future***

# Background of Light Weight requirement



**Environment**

CO<sub>2</sub> and NO<sub>x</sub>

**EU : Regulation  
CO<sub>2</sub> emissions**

**-2008 : 140g/km**

**-2012 : 130g/km**

**-2020 : 95g/km**

**+ Compensation**

**Regulation**

*CAFE*

*fuel economy*

**Light  
Weight**

**▪ Aluminum**

▪ High strength steel

▪ CFRP

▪ Magnesium

**▪ Safety**

- IIHS: e.g. Bumper test

- NHTSA: e.g. SINCAP

- Euro-NCAP

▪ Comfortable

**▪ Stability**

**▪ Drivability**

- Front weight reduction

- Lower center of gravity

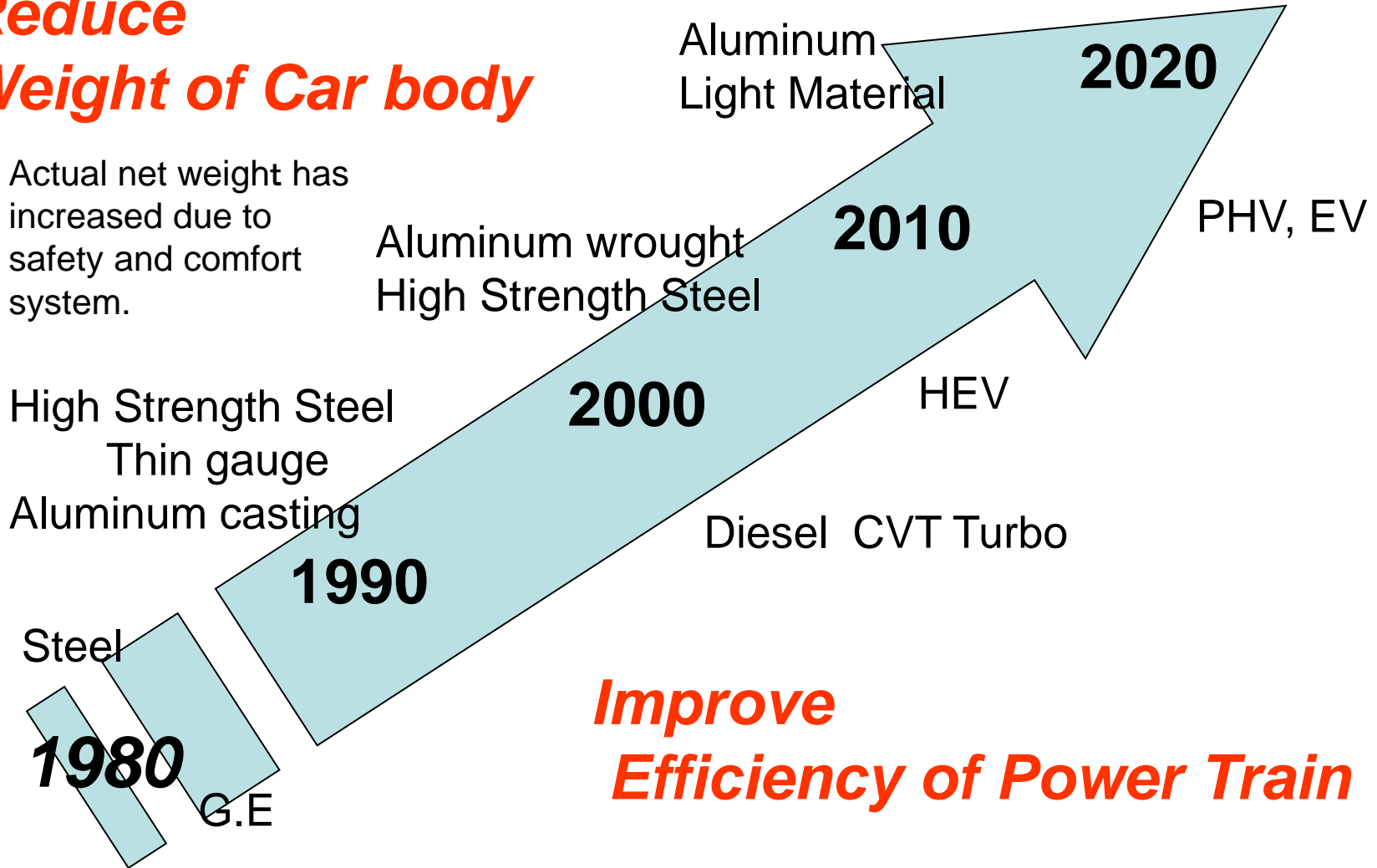
- Electric control system

# CO2 Emission Control

Fuel Economy

## *Reduce Weight of Car body*

Actual net weight has increased due to safety and comfort system.



## *Improve Efficiency of Power Train*

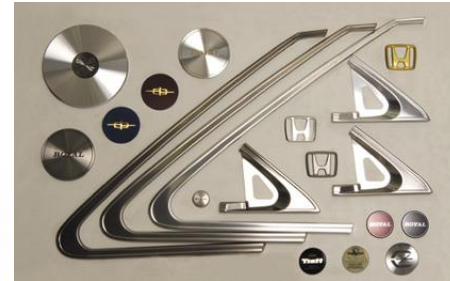
# Aluminum applications



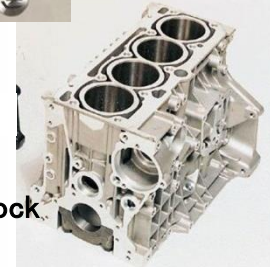
Suspensions



Doors



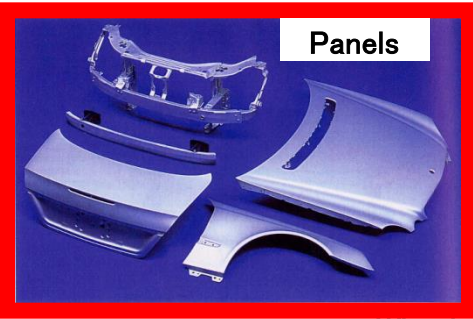
Frames



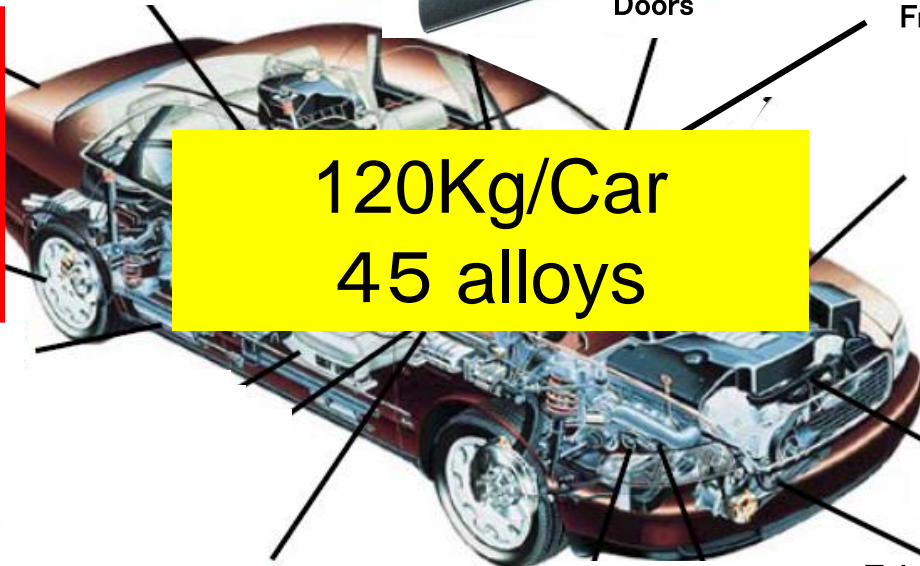
Engine block



Re-infores



Panels



120Kg/Car  
45 alloys

Wheel

Structures

Braking systems

Radiators

Tubes

HE

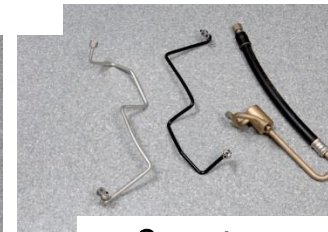


Mult

Covers



Conectors



## BMW5: Aluminum Fr structures



# Aluminum applications for Closure panels

プリウス



リーフ



レジェンド



レヴォーグ



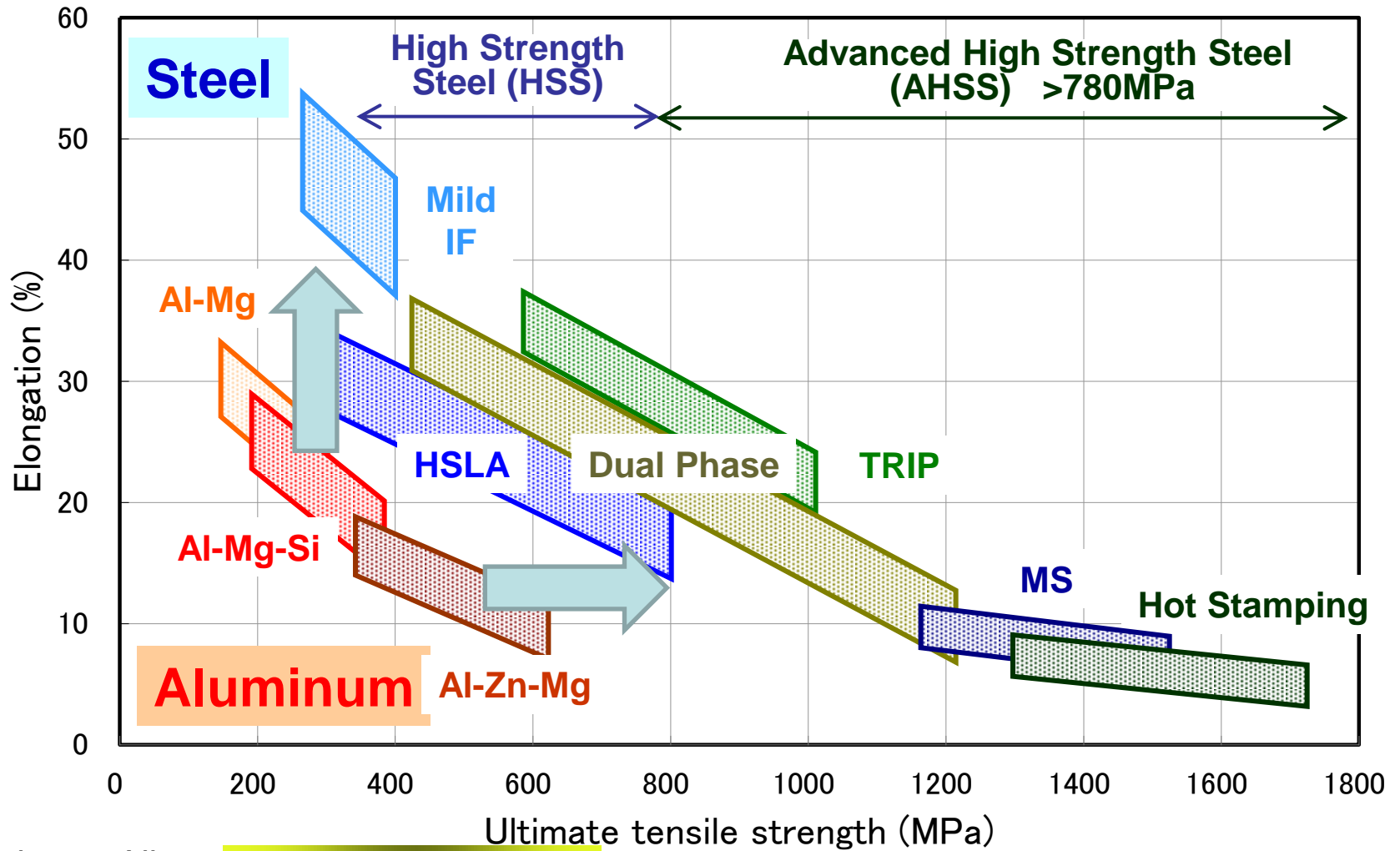
ロードスター



ランサーエボ



# Comparisons of Steel and Aluminum



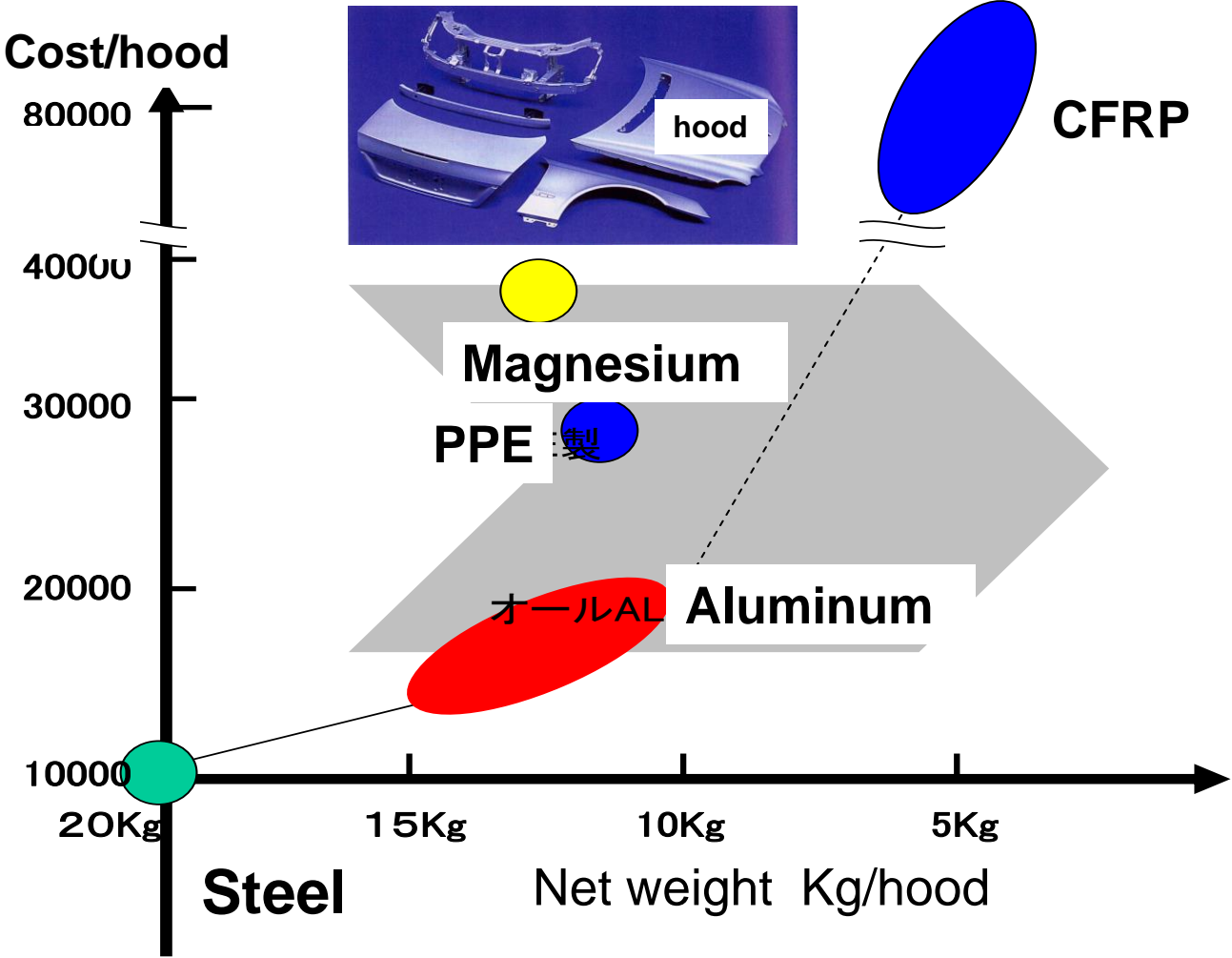
Aluminum Alloy

Cold Stamping

Roll Forming

# Comparisons of parts cost by materials

## HOOD Panels





# Contents

◆ *The background on light weighing requirements of automotive body structures*

◆ ***Light weighing technologies of Closure Panels by Aluminum Alloy***

Advantages of Aluminum on Closure panel applications

Effect of additive on high paint bake response of 6xxx alloy.

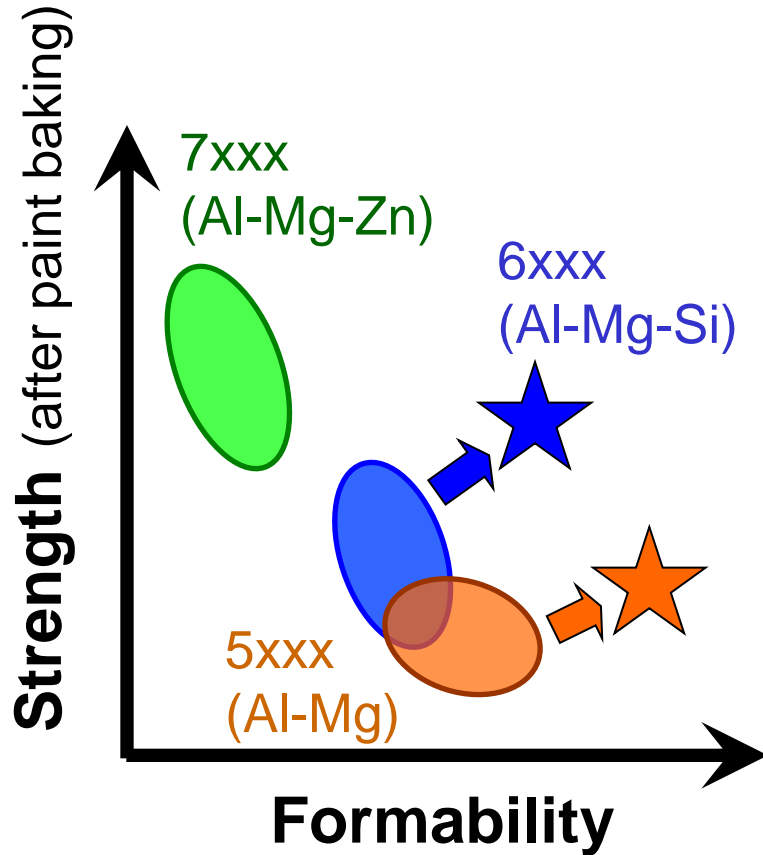
Forming & Joining technologies

◆ *Aspects on light weighing for Automotive body in future*



# New 6xxx alloy development

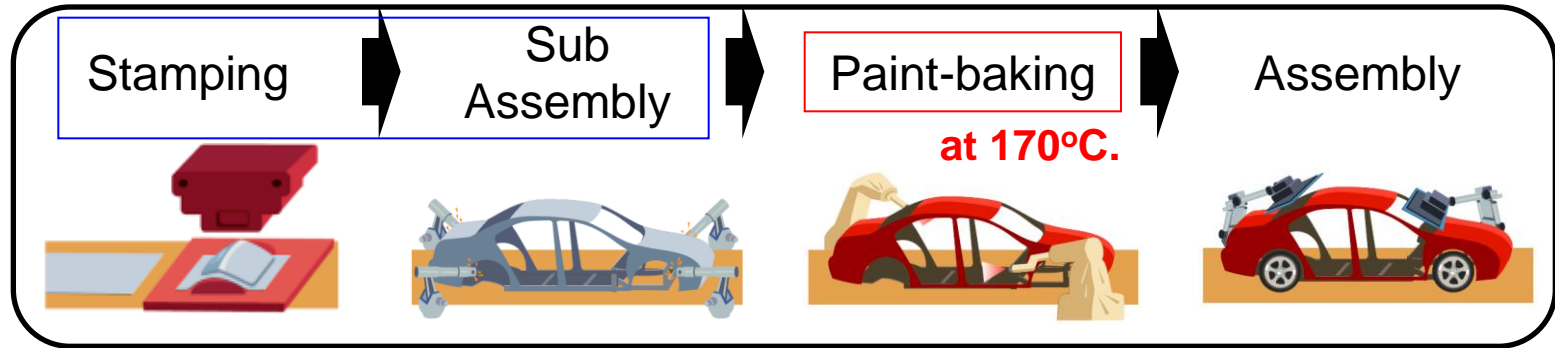
To improve required performance for 6xxx,  
Kobe Steel is working continuously with our customers.



Application	Key words
Panel	Formability <b>Paint bake response</b> Hemming Natural aging control Roping free
Structural parts	Strength Energy absorption

# Motivation of Paint Bake Response improvement

- Manufacturing process of parts at car manufacturers

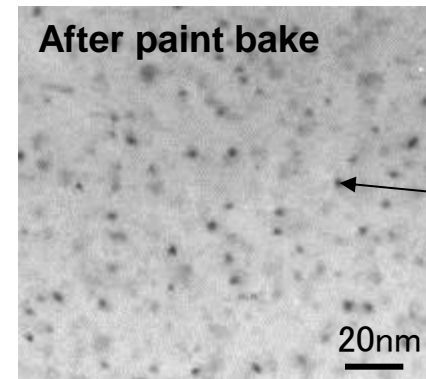


- Mechanical properties of Al sheets

Lower strength for better hemming performance.

Higher Paint Bake Response even at low temperature.

- Microstructure (Transmission Electron Micrograph)



← Strengthening precipitates

# Properties of Developed 6xxx alloy

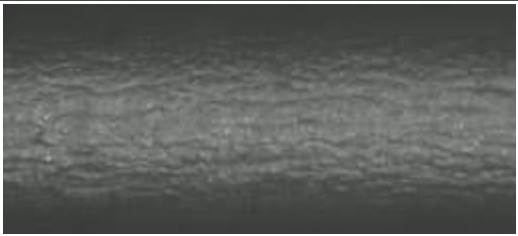
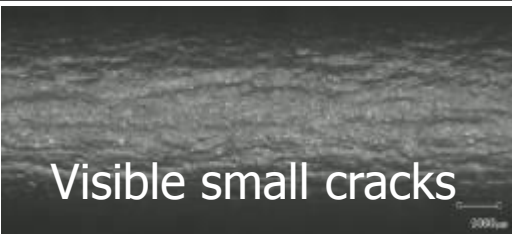
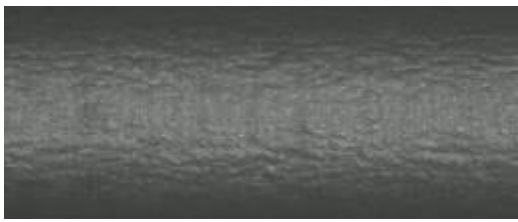
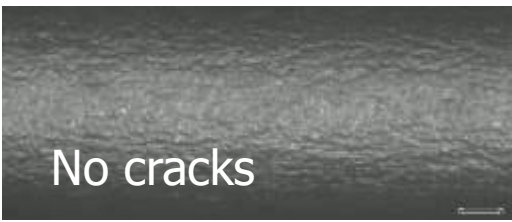
## Chemical composition & mechanical properties of test materials (Lab)

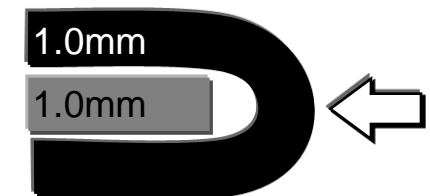
	Chemical composition (wt%)				Tensile property: JIS13A Direction 0° RD						
					Before paint bake					After Bake	
	Si	Mg	Cu	Addi-tive	R <sub>m</sub> MPa	R <sub>PO.2</sub> <sup>*1</sup> MPa	R <sub>PO.2</sub> /R <sub>m</sub>	A <sub>80</sub> %	n-value (5%)	R <sub>PO.2</sub> <sup>*2</sup> MPa	ΔBH (*2-*1) MPa
Conventional	1.0	0.4	0.15	-	237	116	0.49	27	0.30	215	99
Developed	<b>0.8</b>	<b>0.4</b>	-	<b>0.06</b>	186	79	<b>0.42</b>	25	<b>0.34</b>	199	<b>120</b>

## Bending test results (R=0.5, 180 deg.)

Paint bake: 2%st.+185°C,20min

Natural aging for 1 month

	0°	90°
Conventional		
Developed		



# Paint Bake Response at 170°C

Newly developed 6xxx alloy showed;

-better hemming performance.

-higher Paint Bake Response even at low temp (170°C).

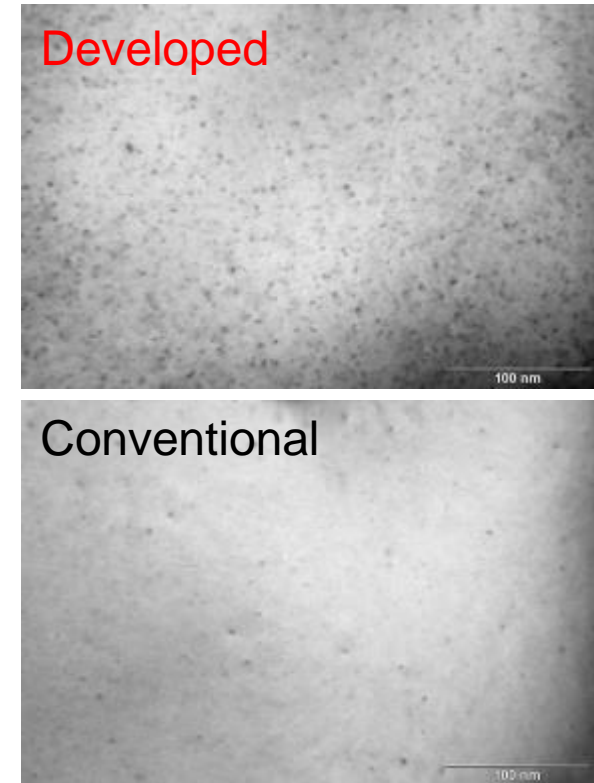
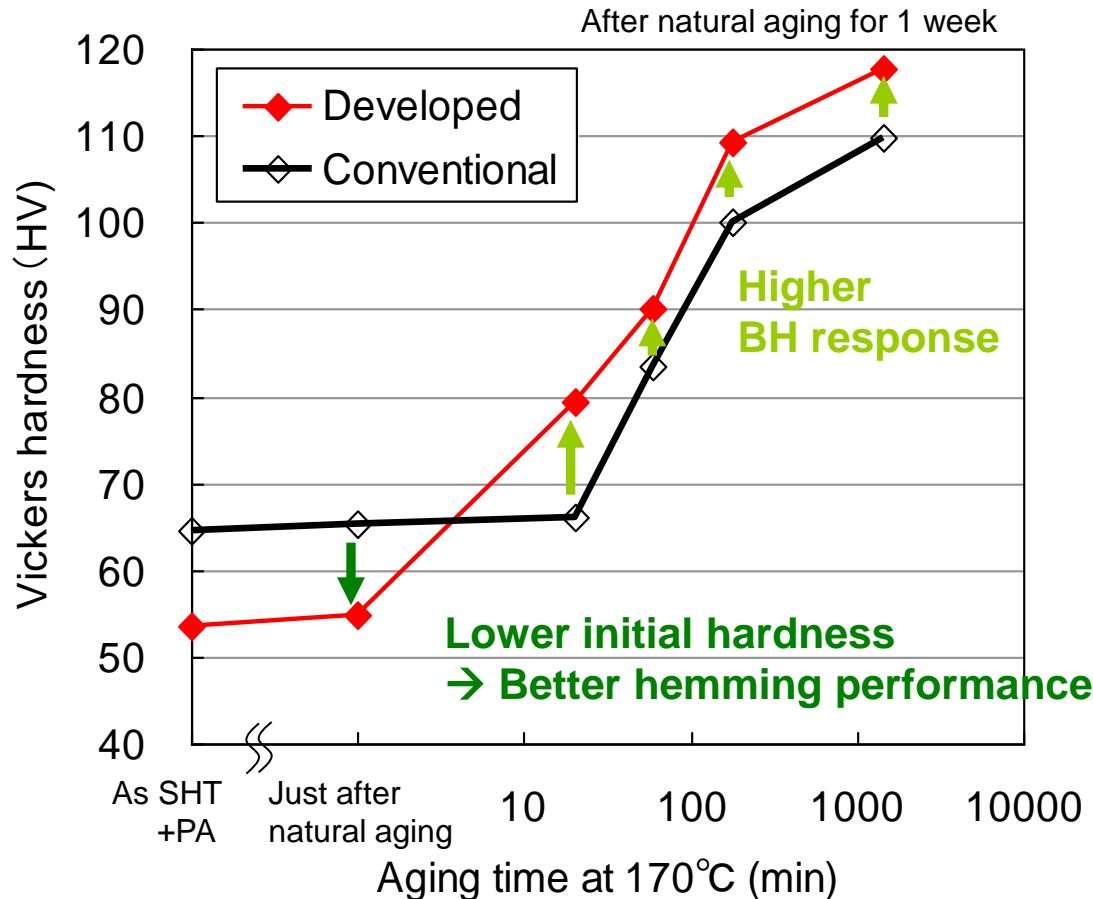


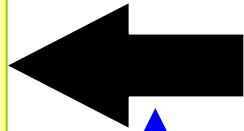
Fig. TEM observations for the samples, aged at 170°C for after 20 min.

# Evaluation of atomic cluster distribution

Higher Paint Bake Response



**Control of atomic cluster**



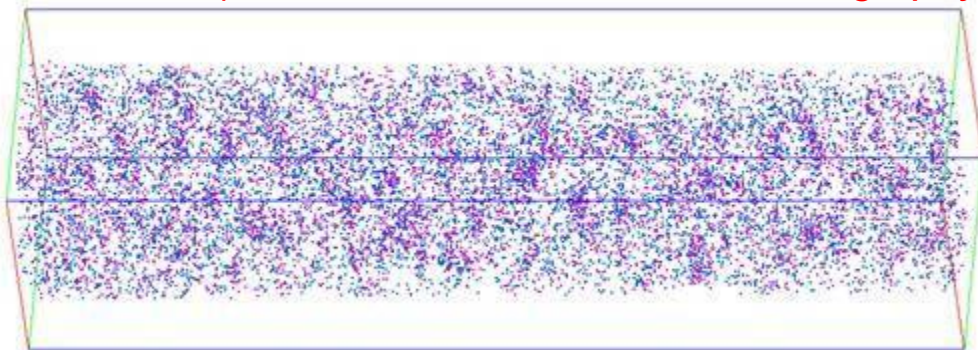
## Approach

- Alloy designing
  - >Contents of Mg and Si
  - >Mg/Si ratio
  - >Additional Elements (Sn)
- Manufacturing process designing

## Evaluation technique

- Mg atom
- Si atom

*Atomic-scale characterization  
(3 Dimensional Atom Probe Tomography)*



10nm



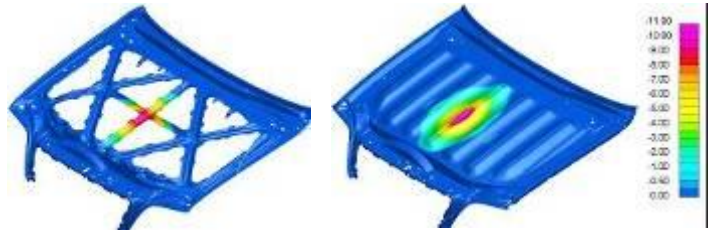
3DAP instrument in Kobe.

# R&D strategy

## Material development

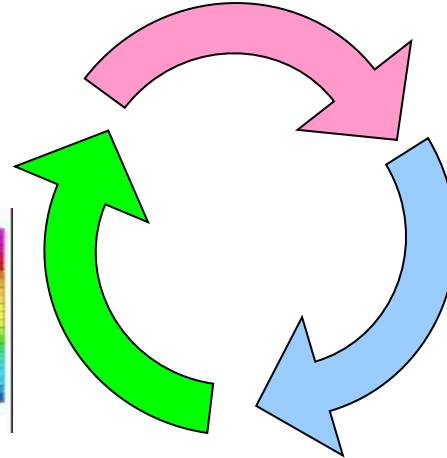
### Product design

Crush behavior  
Thermal distortion control



Conventional

New concept



### Joining

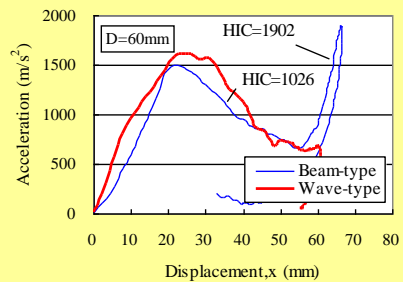
### Forming technology



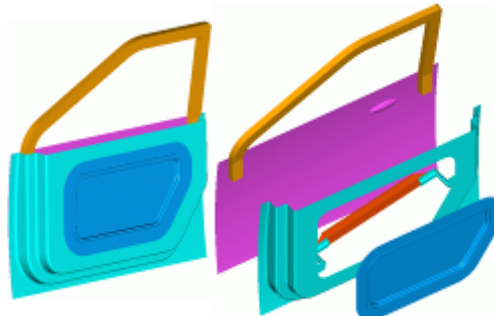
Conventional

New concept

New die design concept for deep drawing



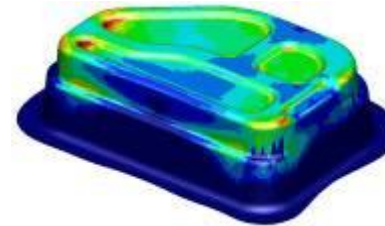
Hood inner design  
for pedestrian  
protection



- EA with side impact; **+16%** vs. conventional Al door
- Cost reduction potential;  
Decrease **number of parts & joints**
- Weight reduction; **-40%** vs. Steel

New door concept study

CAE



Warm forming



# Multi Material Solutions

## New Al-FCW (Al/Steel joining)

- Optimization of
1. Flux (Type/Quantity)
  2. Sheath chemistry
  3. Welding parameters



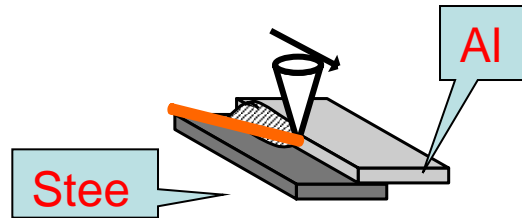
New Al-FCW (1.2Ø)

FCW  
(Flux-cored wire)

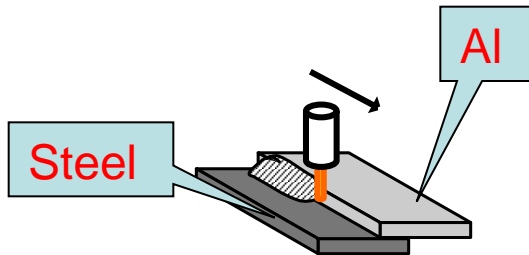


Flux Sheath

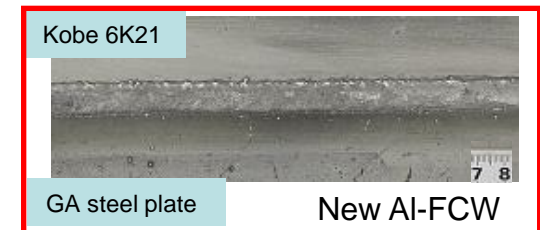
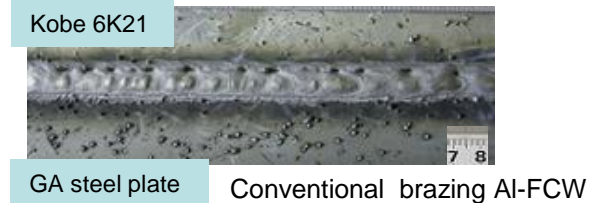
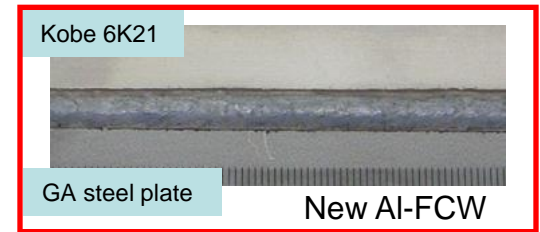
(Improves wettability)



Laser braze welding



MIG braze welding



\* Joint development company (Production / sale)  
Nippon Engineering Industry and Service: Neis Co. Ltd

- Improved weld bead appearance
- Enable to use conventional aluminum welding equipment

# Contents

- ◆ *The background on light weighing requirements of automotive body structures*
- ◆ *Light weighing technologies of Closure Panels by Aluminum Alloy*
  - Advantages of Aluminum on Closure panel applications
  - Effect of additive on high paint bake response of 6xxx alloy.
  - Forming & Joining technologies
- ◆ ***Prospects on aluminum alloy applications for light weight Automotive bodies in the future***

# Mercedes-Benz New C-Class

	L (mm)	W (mm)	H (mm)	W (kg)
EX	4690	1810	1435	1490
New	4595	1770	1445	1500



Low center of gravity

- Hot-formed ultra-high-strength steel
- Ultra-high-strength steel
- Steel
- Aluminium



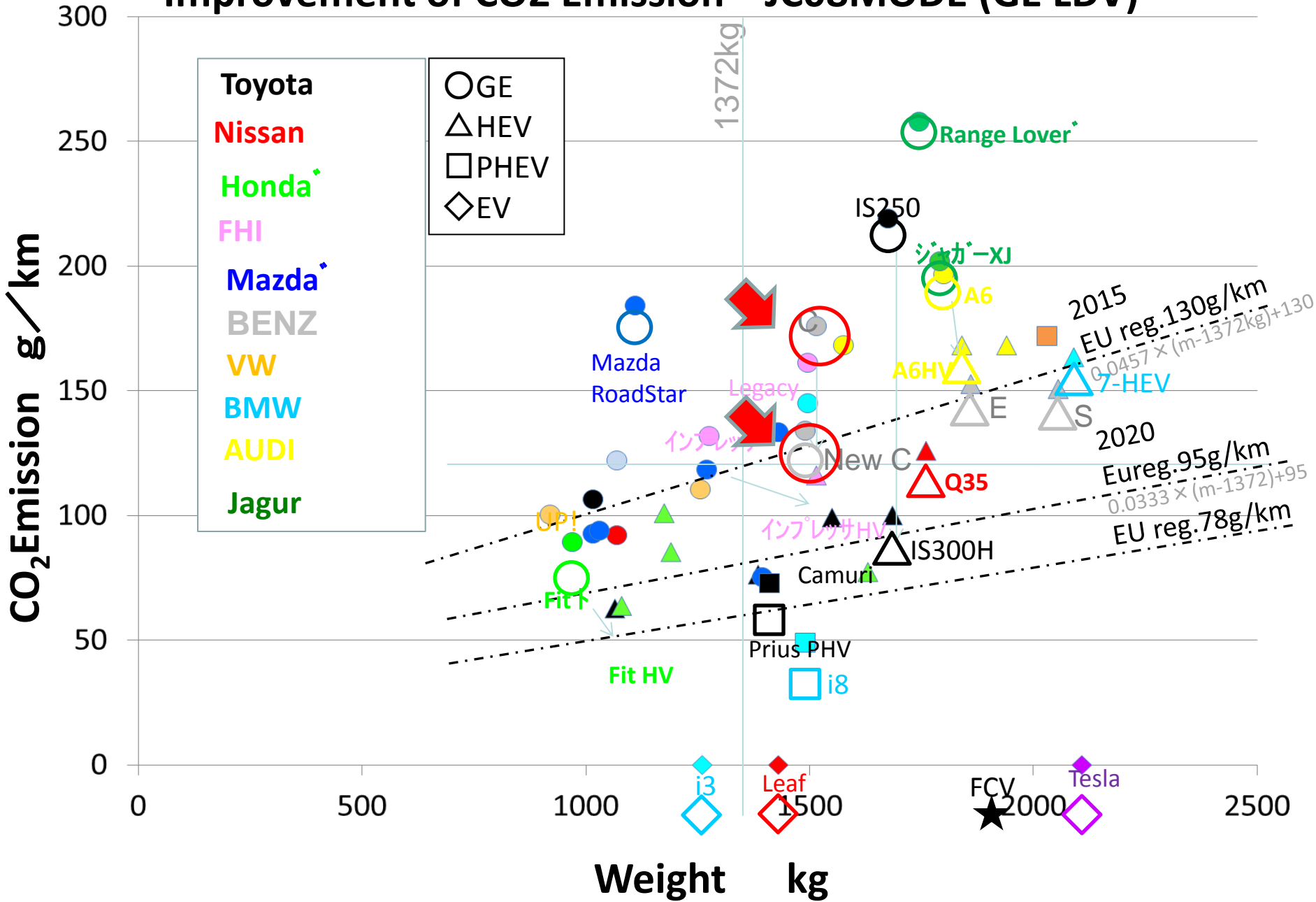
Aluminum 50% in structure parts  
Multi Material body with UHS,AHS

- Aluminium + 39 %
- hot-formed steel parts + 5 %
- ultra-high-strength steels + 1 %



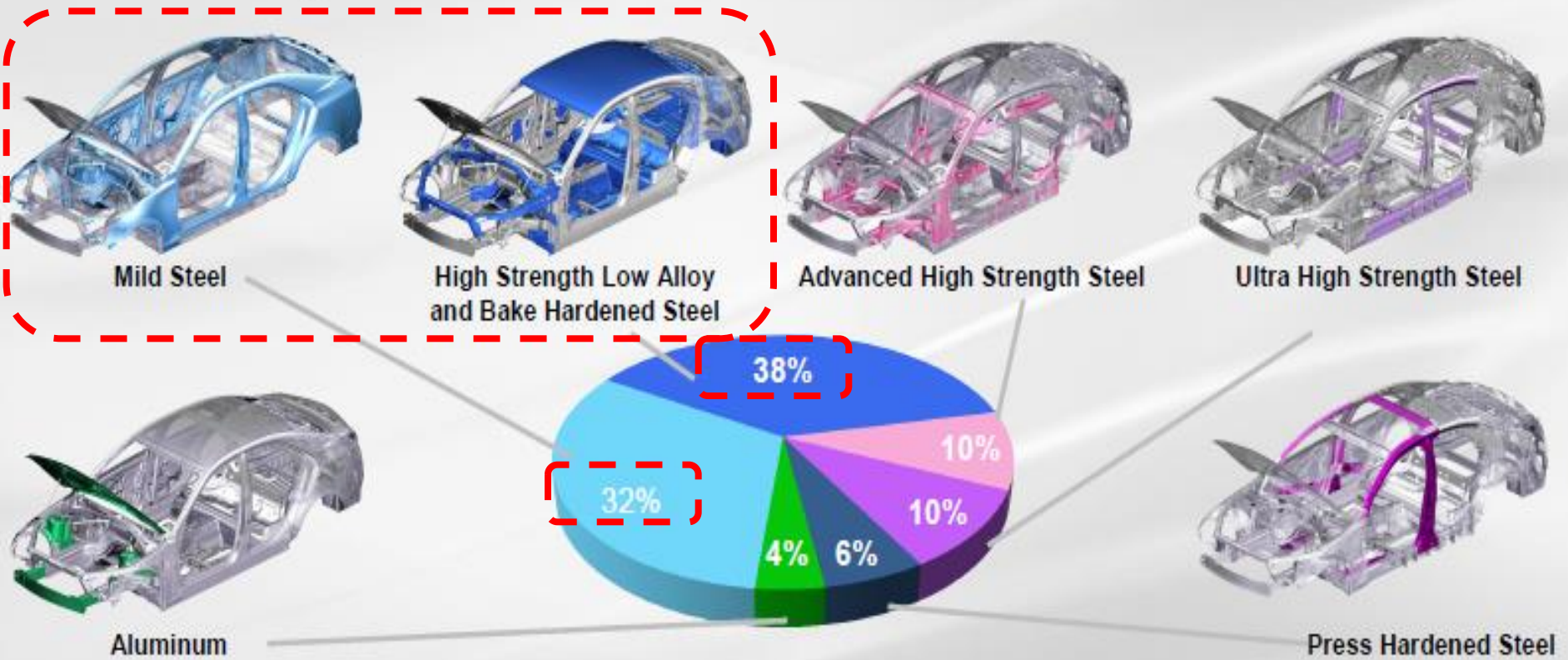
Aluminum Suspension Parts

# Improvement of CO2 Emission JC08MODE (GE LDV)



# MULTIPLE MATERIALS IN BODY-IN-WHITE

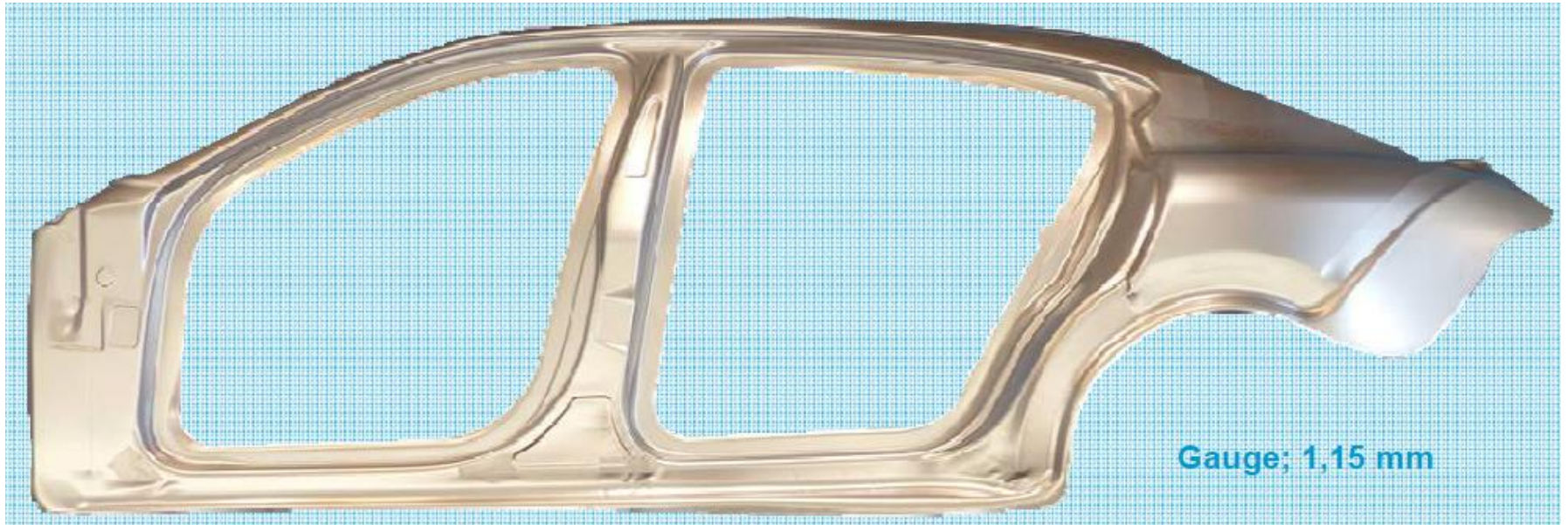
*ATS Example:*



*Material Distribution as a Percent of BIW Mass*

# The Target parts of Aluminum alloy

## Side panel



# Summary

- The light weighting technologies of body structures will be still one of the most crucial solutions for CO2 emission issue. Aluminum will be one of the most capable materials. Nonetheless Cost and material performance need to be improved to be applied widely.
- There is a big potentiality to improve the Bake Hardening response of 6xxx alloys for Automotive parts, introducing additives. The mechanism has been studied.
- The improvement of press forming performance, strength and crush behaviors are crucial for further applications of aluminum in order to be used for deep-drawing parts and structures.

**Thank you for your attention.**

