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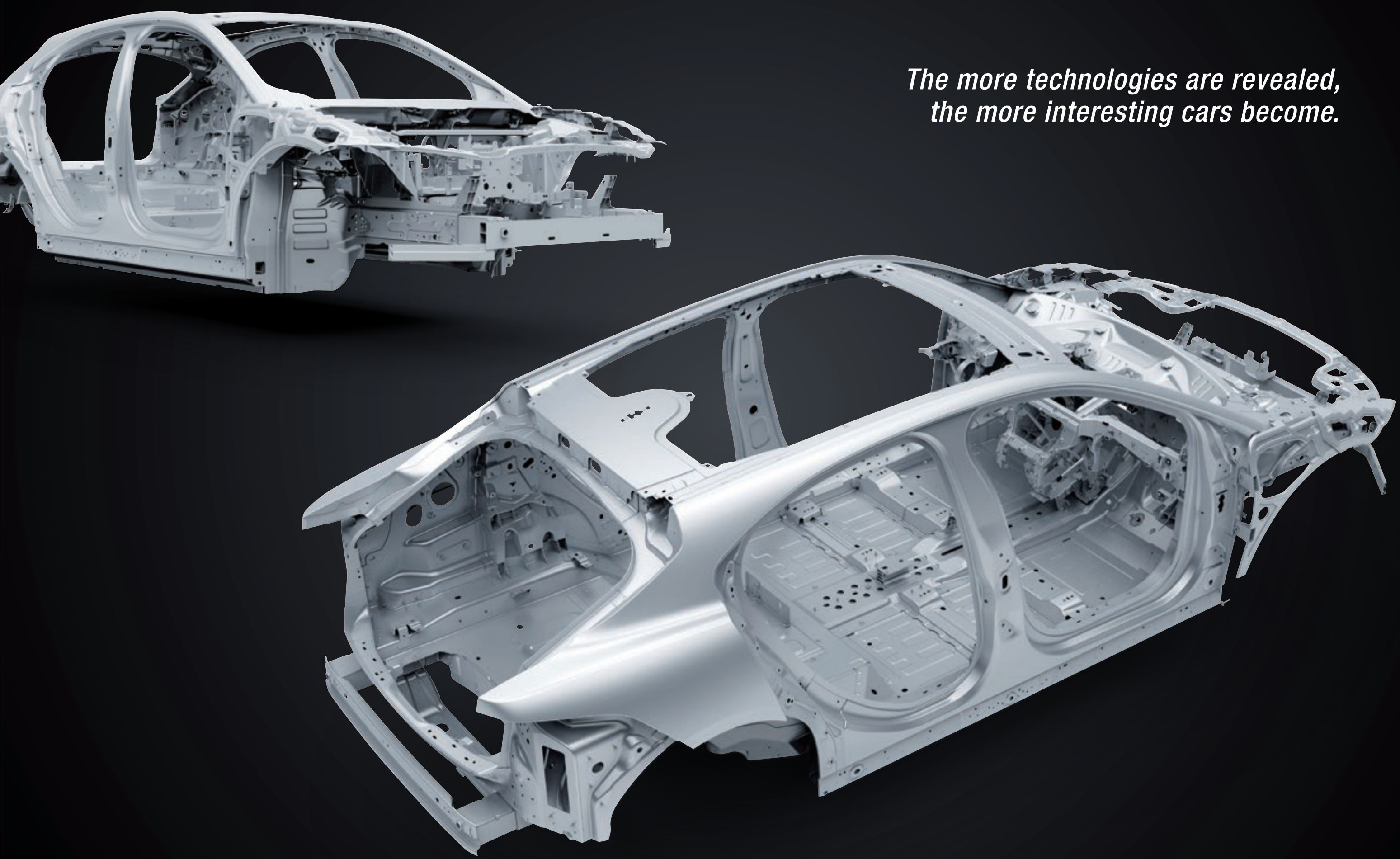
ATZ Extra Issue

Motor Fan illustrated

Special Edition



The more technologies are revealed, the more interesting cars become.

Special Feature **Aluminum Technology 4**

ALUMINUM

Smart Developments

Case Study 01

The impact of the application of aluminum

FORD F-150

Steel has traditionally been the major material used for automobile construction. However, in order to meet today's severe fuel efficiency requirements, the application of other materials is progressing to replace steel. UACJ R&D Division General Manager Akio Niikura talked to us about the ways aluminum is now being applied to automobiles.

The weight of automobiles affects cruising distance, so the main merit of using aluminum for automobiles is its effect on vehicle weight reduction. Aluminum is excellent in terms of strength and ductility, but it cannot match steel in ease of forming because of its inferiority in elongation and shape-freezing properties.

Regarding the materials used for automobile bodies, there are four major trends: all-aluminum; full use of steel, such as ultra-high tensile strength steel; a hybrid of steel and aluminum; and multi-material (steel, aluminum and CFRP), which is currently becoming popular.

Switching to an all-aluminum body structure is progressing in North America. The Ford F-150 took the initiative in this movement. The use of aluminum for large pick-up trucks has had outstanding weight reduction results: in the case of the F-150, the total vehicle weight was reduced by about 320 kilograms. The switch to aluminum began with the larger and luxury vehicles, but when will this trend take off with mass-produced vehicles? The impact on general consumers of the all-aluminum body structure F-150 has been considerable. The fact that such a representative North American vehicle adopted aluminum created powerful images of 'Aluminum is cool' and 'Aluminum is more advanced'. This has provided a major impetus for switching to aluminum. It's estimated that the volume of aluminum body sheets used for a vehicle in North America will dramatically increase by about 10 times, from 6.3kg in 2012 to 61kg in 2025.

The flow of switching to aluminum body panels began with the bonnet, extended to the trunk lid and back door, and then over to the door panels. Which part will be next? "The roof", was Niikura's reply. "To apply aluminum to the roof, it's essential to change the outer side panels to aluminum, and that requires the development of aluminum alloys with better formability. For aluminum manufacturers, the aluminum roof is the ultimate goal."

Akio Niikura, Ph.D.
General Manager,
Development Department II & III,
Research & Development Division,
UACJ Corporation

Impact of the Ford F-150

The F-150 is the best-selling vehicle in North America and the core model of the Ford F-Series of pickup trucks. The complete model change conducted in 2014, with a new steel frame clad in aluminum body panels, attracted a lot of attention in the market. The use of aluminum alloys for the cabin and the cargo area reduced the weight by about 230 kilograms. The reduction in the total body weight of about 320 kilograms improved fuel efficiency by up to 20% compared to previous models.

Small overlap test

Small overlap frontal crash tests are conducted by the Institute for Highway Safety (IIHS). In the test, 25% of a vehicle's front end on the driver's side strikes a rigid barrier at 40mph (64kph). The overlap percentage is much lower than in a conventional 40% off-set crash, which means the strength required for the cabin becomes greater.

In all the crash tests, including small overlap tests, the Ford F-150 has been evaluated as GOOD, the highest score.

The issue of aluminum recyclability

Aluminum alloys feature high recyclability but recycled rolled materials become castings which are now often used for parts like engine cylinder blocks. As the change from internal combustion engines to electric motors intensifies, which parts recycled aluminum alloys can be used for will become an important issue.

Region	Approach
Europe	Long-term target for required fuel efficiency: CO_2 emissions of 95g/km by 2021
North America	Newly introduced fuel-efficiency standards to be reached by 2025: fuel-efficiency of 54.5 mpg (23.2km/ℓ) for passenger cars and small trucks; CO_2 emissions up to 143g/mi (89g/km) for passenger cars
Japan	Target fuel efficiency: 20.3km/ℓ (JC08 Mode) for gasoline-powered passenger cars by 2020

PHOTO: FORD

Case Study 02

Aluminum technologies for the new LS

LEXUS LS

The new LS has the latest structure that uses a considerable amount of aluminum alloy in the outer panels, and ultra-high tensile strength steel in the frame. In addition to the bonnet, trunk lid and front fender aluminum is used for the doors. The application of aluminum has reduced the total body weight by 25% compared to the previous all-steel model, and because the car has four doors, there is an even greater effect on weight reduction.

In general, the inner door panel has a complicated structure, so 5000 series alloys are frequently used because of their high formability. In consideration of dent resistance, 6000 series alloys are used for the outer door panels. However, Toyota decided to use 6000 series for both the inner and outer panels of the new LS.

Other carmakers produce inner panels in three parts, but the LS panels are formed as single pieces. This is largely a result of Toyota's excellent stamping technology, with aluminum manufacturer UACJ's backstage support.

Spring-back emerges as a problem when considering changing to one-piece aluminum inner door panels, because of its inferior formability and shape-freezing properties. Most European carmakers have stamping lines with five to six processes, but Japanese carmakers have production facilities with four processes. One drawing process is sufficient for steel, but aluminum requires two. This means that other processing has to be carried out by the remaining two processes. The high-level stamping technology which forms aluminum in four processes has been developed by Toyota Motor.

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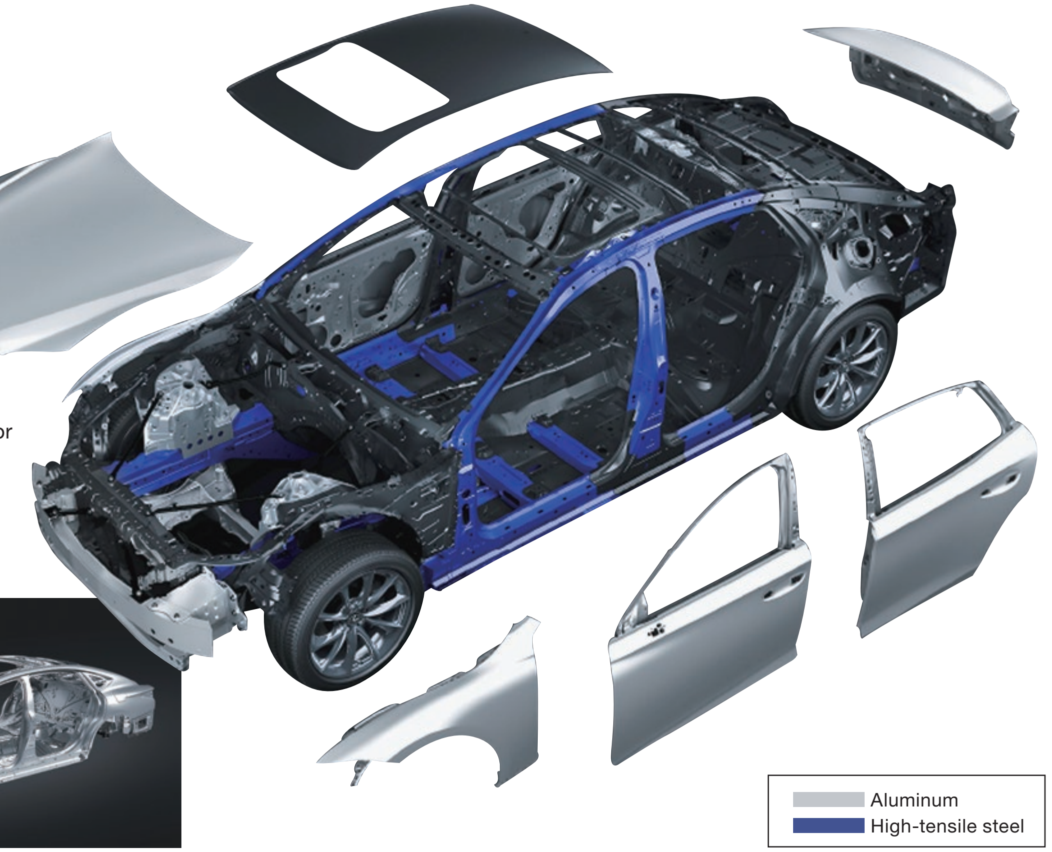
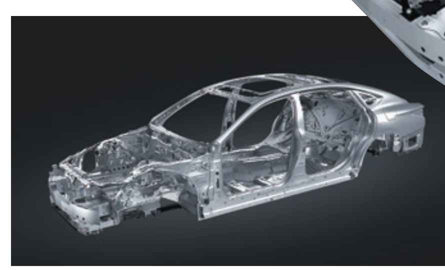
(Motorfan Illustrated Vol.138)

LS500

For the new LS body, aluminum alloys are used for the bonnet, trunk lid, front fender, suspension tower, bumper beams and doors.





Case Study 03

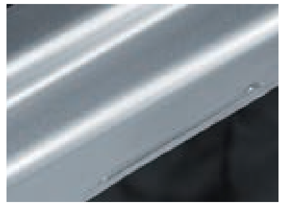
Evolving Joining Technologies for Aluminum

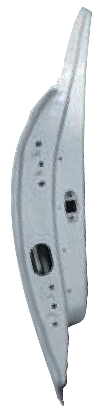
LEXUS LS

← Toyota's LSW (laser screw welding) offers various advantages such as increased productivity and short pitch welding.

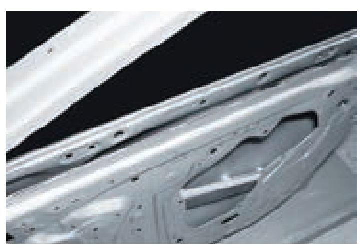
→ SPR (self-piercing riveting) is frequently used because aluminum has high thermal conductivity and it is slightly difficult to spot weld.

↓ Fine welding beads are produced by laser seam welding. Laser welding suppresses thermal distortion to a minimum.

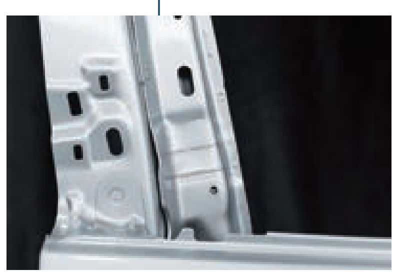




←↑ This photograph shows how deeply the alloy was drawn to produce this inner door panel. 6000 series aluminum alloys are used for both the inner and outer door panels of the LS.



↑ With the LS, the frame is formed as a single unit. The outer door panels are reinforced by welding sheets of a different thickness using TB (tailored blanking).



←↑ The part resembling a strip is where FSW (friction stir welding) for tailored blanks has been conducted.

The aluminum alloy doors of the Lexus LS are a showcase for joining technologies. In addition to the hemming which is regularly used for the outer and inner panels, the appropriate technologies used for each job include LSW, SPR, FSW, FSSW, and laser welding. Tailored blanks are also used. The materials technology, forming technology and joining technology established through the manufacture of the aluminum alloy doors for the LS will be applied to future models. UACJ's Motonobu Hachino says that he is eagerly looking forward to that.

Motonobu Hachino

Manager
Development Department II,
Research & Development Division,
UACJ Corporation

FSW/FSSW

Friction stir welding (FSW) is a joining technology that involves the use of a tool with a pointed revolving tip that is pressed against the metal, which is then softened by friction-generated heat. This plasticized material is used to join pieces of metal together. This method has many benefits, including low levels of distortion and residual stress, and less significant reduction in strength when exposed to heat.

Evolving aluminum joining technologies

Various types of joining technologies for aluminum have been developed and put to practical use, ranging from MIG welding and YAG laser welding to mechanical joining and binding.
The AUDI A8 adapts different types of joining tools and methods, such as flow drill screws, punch rivets, mechanical clinching, MIG welding, and binding according to the points of application.

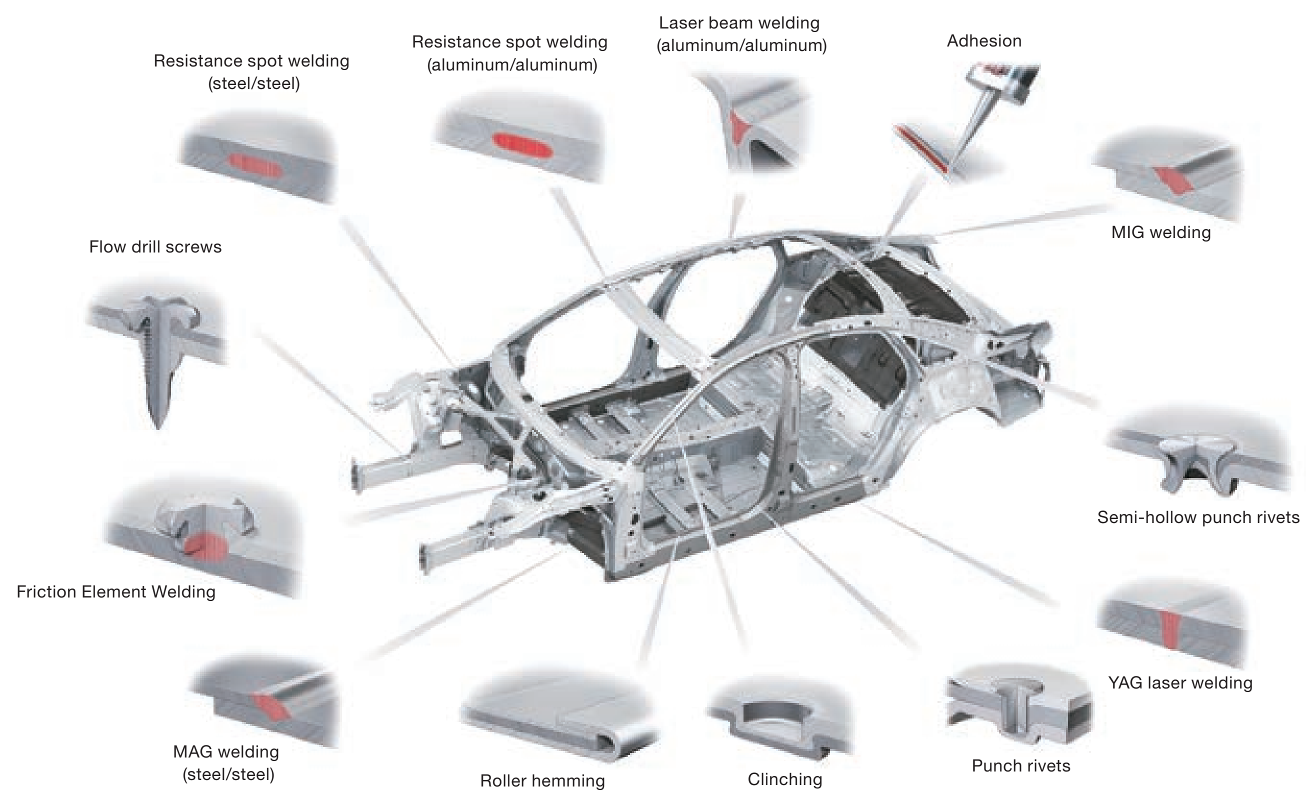


PHOTO: AUDI/Hiroya YAMAGAMI

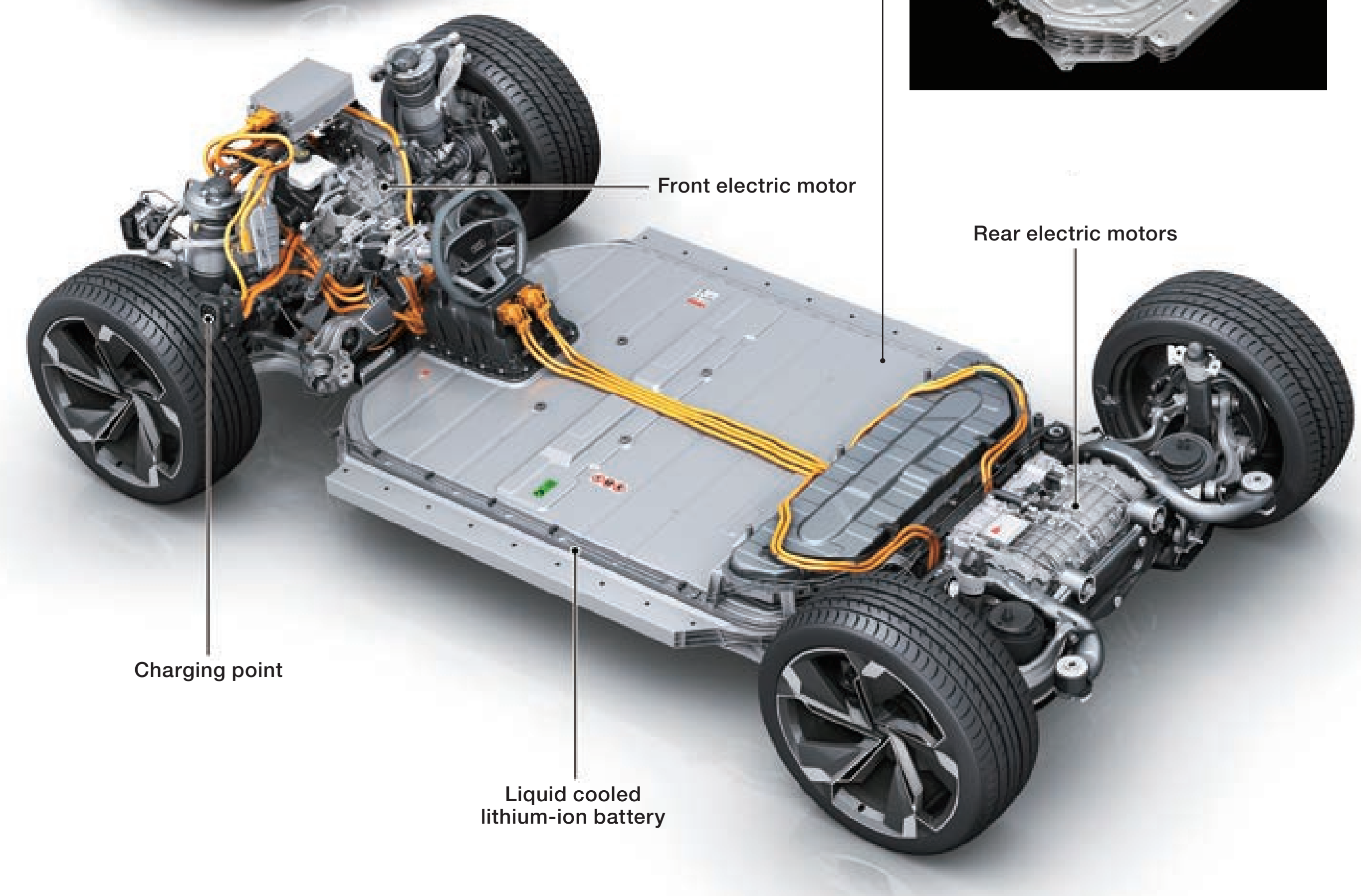
Case Study 04

The Audi e-tron EV platform

EV Platform

Audi e-tron Sport concept

The large-capacity lithium-ion battery loaded on the Audi e-tron is made up of aluminum alloy modules, each containing 12 ‘pouch’ cells. To produce the battery pack, the modules are placed in an aluminum alloy housing.



Regarding the structure of vehicles which are rapidly making their way to being electric-powered, it is now becoming standard to lay out the lithium-ion batteries in an aluminum frame positioned under the floor as part of the body structure. Tesla took the initiative and the BMW i3 was the pioneering model for this. Audi’s e-tron has adopted a similar structure and Jaguar’s I-PACE displays the same concept. The mileage of an EV depends on battery capacity, but the greater the capacity of the loaded batteries, the heavier the total vehicle weight becomes. That is why the use of lightweight aluminum alloys is favored. For example, the Audi e-tron’s battery housing consists of 47% aluminum extruded shapes, 36% aluminum sheets, and 17% aluminum cast products. Despite being made of aluminum, the total weight of the system reaches up to 700kg. Considering the structure in terms of shock being dispersed during a side collision, thermal management, and other factors, an aluminum frame can now be regarded as the standard for an EV platform.

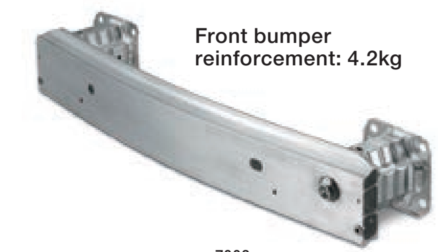
Case Study 05

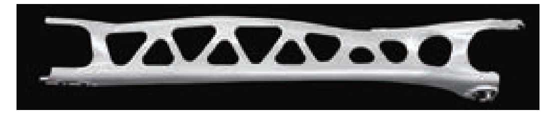
MX-5 with lightweight properties

Mazda MX-5

Aluminum alloy front bumper

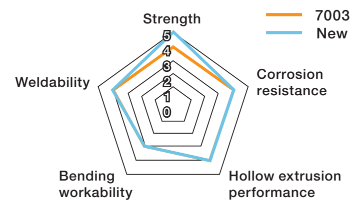
The Mazda MX-5 (ND) front bumper reinforcement uses a 7000 series high-strength aluminum alloy newly developed by UACJ.

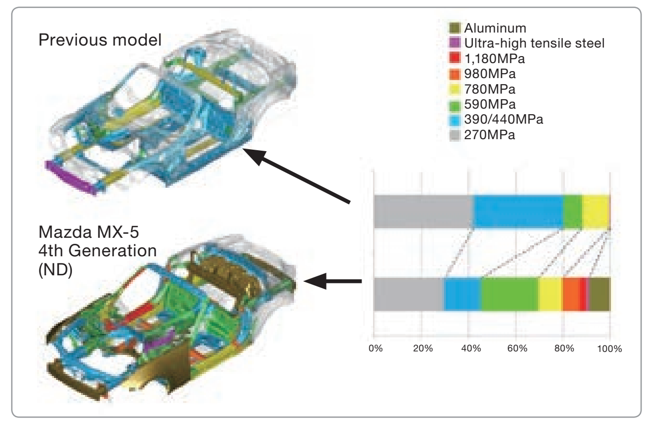




Aluminum alloy power plant frame

The power plant frames used for the MX-5 are press-formed products made of 6000 series high-strength aluminum alloy plate for structural purposes produced by UACJ.





Aluminum alloys have been widely used in the MAZDA MX-5 to create a lightweight but highly rigid body.

Among the aluminum components used for the Mazda MX-5, the bumper reinforcement is of special interest. In order to meet the increasingly strict collision safety standards, the performance required for front bumpers is becoming very high. Regarding the MX-5, further weight reduction was achieved while at the same time securing a safety performance of the highest level. Reducing the weight of the components which are the furthest from the vehicle’s center of gravity is effective not only for improving fuel efficiency but also for increasing maneuverability.

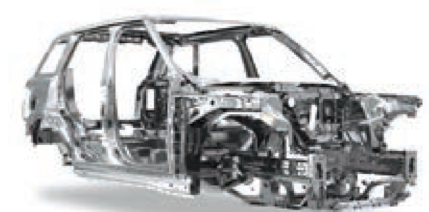
Further weight reduction has been gained by using the 7000 series high-strength aluminum alloy extruded shapes newly developed by UACJ.

TESLA MODEL-S

The chassis of the Tesla Model-S has an all-aluminum frame structure. The battery cells are arranged beneath the flat floor. Aluminum is also used for all the body panels.

JAGUAR **I-PACE**

The I-PACE is the SUV model of Jaguar’s first all-electric vehicle. From its aluminum alloy platform to its body panels, the I-PACE features aluminum construction.



Range Rover **Sport**

Based on knowhow accumulated through the development of the Jaguar XJ, this is the first SUV to feature an all-aluminum monocoque body design.

PHOTO: AUDI/MAZDA/JAGUAR/LAND ROVER/MFi

Case Study 06

A8 with a Multi-material Body

AUDI A8

The multi-material Audi space frame

- Aluminum alloy sheet
- Aluminum extruded shapes
- Aluminum cast products
- Ultra-high tensile strength steel sheet
- Steel
- CFRP
- Magnesium

Audi's new model, the A8, is a multi-material-oriented vehicle using ultra-high tensile strength steel, mild steel, CFRP, magnesium and other materials while featuring the multi-material Audi space frame with aluminum as its core. Adoption of aluminum alloys has the special merit of providing reliability in a lightweight and highly rigid space frame structure. The body panels are all-aluminum, and for the doors in particular 6000 series aluminum alloys are used for both the inner and outer panels. For the base of the A pillars, where aluminum alloy sheets were used for the 2015 Audi R8, steel is employed in the new Audi A8. This is thought to symbolize multi-materialization.

Guidelines for aluminum alloy choices

The aluminum sheets typically used as body panels often include non-heat-treatable 5000 series alloys and heat-treatable 6000 series alloys for the reasons of strength, formability and corrosion resistance. As for formability, the 5000 series excels the 6000 series. The 1000 series, excellent in corrosion resistance and workability, are used for heat insulators, and the 3000 series are used for tubing. The 4000 series are used for compressor wheels and the 6000 series for forged wheels.

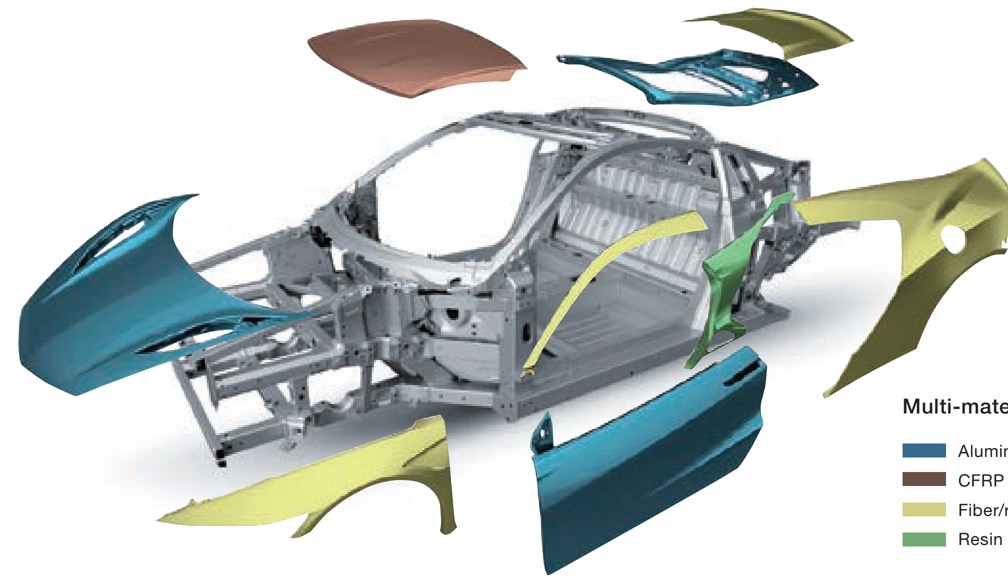
Through collaborative work according to the requests and purposes of automobile manufacturers, UACJ is realizing the production of a variety of aluminum automobile parts.

Mineo Asano
Manager
Product Engineering Division
Nagoya Works
UACJ Corporation

Case Study 07

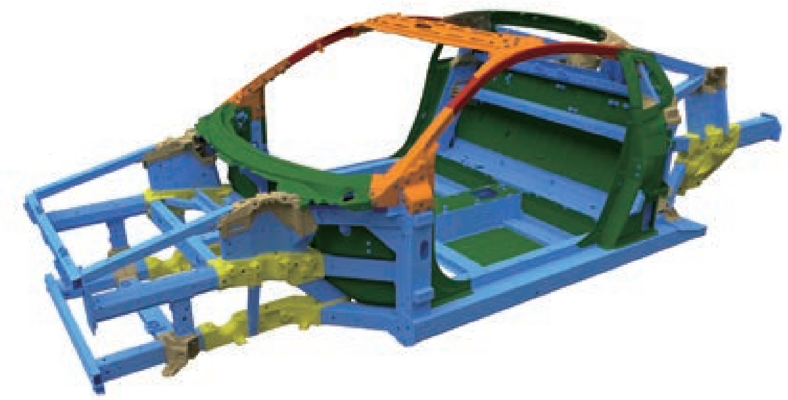
NSX with a Multi-material Body

HONDA NSX



Multi-material body panels

- Aluminum alloy sheet
- CFRP
- Fiber/resin compound (SMC)
- Resin



Space frame using multi-materials

- Aluminum alloy sheet
- Aluminum extruded shapes
- 3DQ ultra-high tensile strength steel tube
- Ablation cast aluminum
- Gravity die cast aluminum
- Steel

The NSX for the 21st century is not an all-aluminum body structure, but a multi-material space frame structure using aluminum, ultra-high tensile strength steel, resin and other materials. Mainly high-strength extruded aluminum shapes are used. Aluminum alloy accounts for about 79% of the whole structure; other materials include 13.5% of steel and 7.4% of resin. Structural joining techniques such as SPR (self-piercing riveting), FDS (flow drill screw) and roller hemming are frequently used.

Alloy evaluation

- ✓ (red): Very good
- ✓ (black): Good
- A: Good
- B: Standard
- C: Inferior

			Features required for aluminum alloy						Major alloy for choice
			Strength	Formability	Corrosion resistance	Arc weldability	Spot weldability	Extrusion performance & Forgeability	
Classification and Uses	Sheets	Panels (outer panels)	✓ (red)	✓ (red)	✓ (red)		✓ (black)		5000/6000
		Structural parts	✓ (red)	✓ (red)	✓ (red)	✓ (red)	✓ (black)		5000/6000
		Non-structural parts		✓ (red)	✓ (red)		✓ (black)		1000/3000/5000/6000
	Extruded shapes	Structural parts	✓ (red)	✓ (black)	✓ (red)	✓ (red)	✓ (black)	✓ (red)	6000/7000
	Forged products	Structural parts	✓ (red)	✓ (black)	✓ (red)			✓ (red)	6000
Alloy Non-heat-treatable	1000 series	Pure aluminum	C	A	A	A	A	A	
	3000 series	Al-Mn	C	A	A	A	A	A	
	5000 series	Al-Mg	B	A	A	A	A	C	
Alloy Heat-treatable	2000 series	Al-Cu	A	C	C	C	C	B	
	6000 series	Al-Mg-Si	B	B	A	B	B	A	
	7000 series	Al-Zn-Mg	A	C	C	B	C	B	

PHOTO: AUDI/HONDA

Case Study

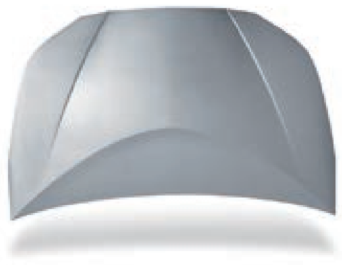
08

Automobile parts created from aluminum alloy

Aluminum Materials

6000 series Aluminum Alloy for Body Panels

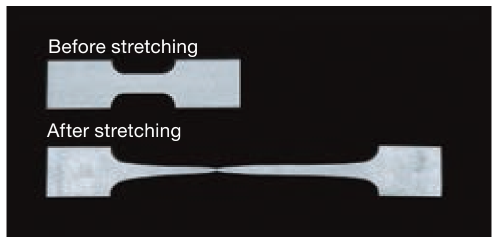
Producing body panels from aluminum alloy is a highly effective way to reduce weight and enhance fuel efficiency.
Currently, 6000 series aluminum alloys are the type most commonly used in body panels, and since they have “bake-hardenability,” they can be strengthened during the coat baking process.
The 6000 series aluminum alloys are characterized by low strength during the stamping process, making them highly formable, but the coat baking process makes them substantially stronger.

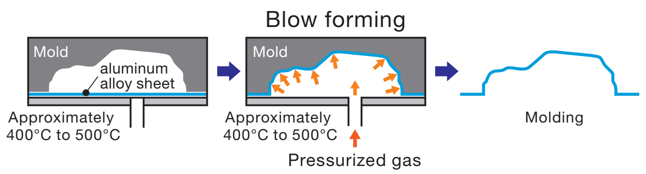


Required properties of body sheets
- Bake-hardenability
- Formability
- Hemmability
- Dent resistance
- Corrosion resistance
- High-luster paint finish

Superplastic Aluminum Alloy Sheet

A superplastic material is one that can be stretched by a factor of more than several hundred percent when heated to high temperatures.
Using the blow molding method (using pressurized air to force heated material into metal molds), superplastic aluminum alloy sheet can be used to freely create any body shape.



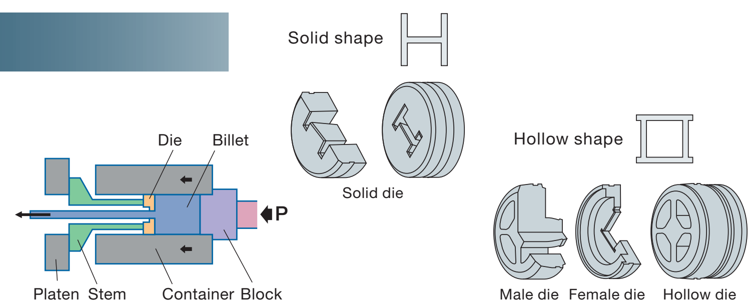


Aluminum Alloy Design Sheet

UACJ manufactures luminous aluminum alloy design sheet with a focus on a level of sheen which can hardly be found anywhere else in the world. With this material, superior designs can be achieved through chemical and electrolytic polishing.
Aluminium panels with surfaces beautifully processed and treated with hairlines and other designs are widely used for cockpit interior decoration.
The beautiful sheen of aluminum sheets surely provides an incentive to choose them instead of resin.

Aluminum Extruded Shapes

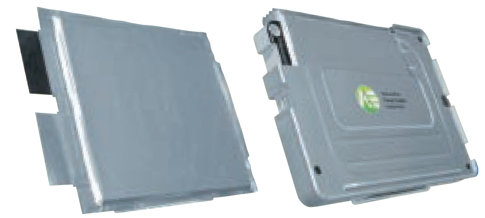
With extrusion, it is possible to produce high-precision components in a diverse range of shapes including hollow structures and complex cross-sectional shapes. Aluminium extruded shapes optimal for the production of parts with a constant cross-section and long length, such as bumper beams. It’s now common to find space-frame structures made of aluminium extruded shapes in large SUVs and electric vehicles.



Aluminum Alloy for Lithium-ion Batteries

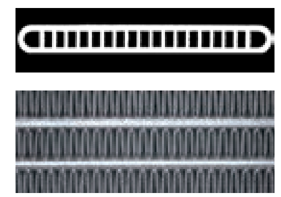
Lithium-ion batteries are becoming the mainstream and development of the next-generation batteries is progressing. Aluminum alloy plays a major role as a material used to produce lithium-ion batteries.

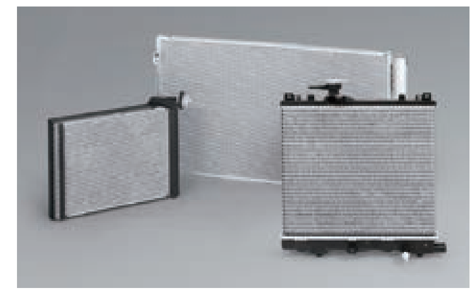
Aluminum materials used in LIB
- Aluminum cathode foils
- Housing cases
- Busbars
- Disclosure sealers
- Laminated pouches


Lithium-ion battery cell & Module

Aluminum Materials for Heat Exchangers

Heat exchangers for automobiles are mostly made of aluminum. They are produced by assembling multi-hole flat tubes and corrugated brazing sheets, which are combined into a single unit by brazing.
To reduce weight and enhance performance, heat exchanger materials are made thinner, so corrosion proofing is vital.





Aluminum Alloy for Turbochargers

Compressor wheels (C/W) for turbochargers are now mostly produced with low-pressure casting, but the number of products produced by machining aluminum bars is increasing.
Only a few companies in the world, including UACJ Foundry & Forging Corporation, have the ability to manufacture both cast and machined products.
UACJ's aluminium precision cast compressor wheels hold the world’s top share.


C/W (Cast products)
C/W (Machined products)

Aluminum Alloy for Suspensions

As safety critical components, suspension parts need to be highly reliable.
In order to enhance riding comfort and driving stability, use of high-strength forged aluminum alloy is expanding for axle parts such as suspension arms and hub carriers, and other parts.


Suspension arms


Shock absorbers

Popular Aluminum Alloys for Automobiles

Various types of aluminum alloys are used for automotive components according to the strength, formability and corrosion resistance required at each point of application.

Alloy series	AA*1 Equivalent alloys	UACJ (by quality)	Tensile strength (N/mm²)	Proof stress (N/mm²)	Elongation (%)	Sheet	Extrusion	Characteristics of materials
1000 Al	1085	A85-H26	120		15	✓		Luminous aluminum alloy sheet Surface quality: LF, HB
		A370-O	85		40	✓		Luminous aluminum alloy sheet Surface quality: BF, MF
		A370-H24	120		23	✓		Luminous aluminum alloy sheet Surface quality: BF, MF
2000 Al-Cu	2013	113S-T6	400	375	12		✓	High-strength alloy for extrusion Hollow extrusion performance: Good
	2014	2014-T4	420	285	20		✓	High-strength alloy for extrusion
	2014	2014-T6	480	410	13		✓	High-strength alloy for extrusion
	2017	2017-T4	440	275	22		✓	High-strength alloy for extrusion
	2024	2024-T4	470	325	19		✓	High-strength alloy for extrusion
	2014	2014-T6	480	410	13		✓	High-strength alloy for forging Forgeability & machinability: Excellent
		2618-T6	440	370	10		✓	High-strength alloy for forging Forgeability & machinability: Excellent
		CG29-T6	520	400	14		✓	High-strength alloy for forging Forgeability & machinability: Excellent
3000 Al-Mn		3003-O	115	40	40		✓	Alloy for tubing Hollow extrusion performance: Good
4000 Al-Si	4032	4032-T6	380	315	9		✓	Wear-resistant alloy for forging Forgeability, machinability, corrosion resistance: Good
		TF068-T6	380	245	10		✓	Wear-resistant alloy for forging Forgeability, machinability, corrosion resistance: Good
		SC100-T6	440	390	8		✓	Wear-resistant alloy for forging Forgeability, machinability, corrosion resistance: Good
		TF128-T6	430	380	8		✓	Wear-resistant alloy for forging Forgeability, machinability, corrosion resistance: Good
5000 Al-Mg	5052	52S-O	205	105	28	✓		Alloy for body panels n value *2=0.26, r value=0.70
	5182	GM145-O	270	120	28	✓		Alloy for body panels n value *2=0.33, r value=0.55
	5022	GC45-O	280	140	32	✓		Alloy for body panels n value *2=0.31, r value=0.70
	5052	52S-O	205	105	28	✓		High-strength alloy for structural purposes Shear strength: 120N/mm²
	5454	D54S-O	225	100	27	✓		High-strength alloy for structural purposes Stress corrosion cracking resistance: Excellent
	5154	A254S-O	240	115	27	✓		High-strength alloy for structural purposes Stress corrosion cracking resistance: Good
	5083	183S-O	290	145	24	✓		High-strength alloy for structural purposes Shear strength: 170N/mm²
	5110A	257S-O	110		30	✓		Luminous aluminum alloy sheet Surface quality: HB, BF, MF
	5110A	257S-H24	150		15	✓		Luminous aluminum alloy sheet Surface quality: HB, BF, MF
	5657	F57S-H26	170		12	✓		Luminous aluminum alloy sheet Surface quality: LF, HB, BF
	5252	B152S-H24	220		10	✓		Luminous aluminum alloy sheet Surface quality: BF
	5154	254S/5154-O	240	117	27		✓	High-strength alloy for extrusion
	5083	5083-O	290	145	25		✓	High-strength alloy for extrusion

*1 AA: The Aluminum Association (U.S.A.)
*2 Average value between 2% and maximum load

*Baking conditions for BH-type alloy for body panels:
Test value after applying 2% pre-distortion and 20 min at 170°C

Note: The list is made for each alloy series giving priority to the point of application for automobiles, so some material qualities may be indicated repeatedly. The figures are measures of central tendency, not guaranteed values.

Alloy series	AA*1 Equivalent alloys	UACJ (by quality)	Tensile strength (N/mm²)	Proof stress (N/mm²)	Elongation (%)	Sheet	Extrusion	Characteristics of materials
6000 Al-Mg-Si	6116	SG712-T4	240	130	28	✓		Alloy for body panels, High-BH type Proof stress after baking: 205N/mm²
	6116	SG712-T4	245	135	30	✓		Alloy for body panels, High-forming type Proof stress after baking: 170N/mm²
	6005	TM30-T4	210	110	27	✓		Alloy for body panels, High-BH type Proof stress after baking: 195N/mm²
	6111	TM66-T4	240	115	29	✓		Alloy for body panels, High-BH type Proof stress after baking: 210N/mm²
	6061	561S-O	120	45	34	✓		High-strength alloy for structural purposes Stress corrosion cracking resistance: Good
	6061	561S-T6	315	275	17	✓		High-strength alloy for structural purposes Shear strength: 205N/mm²
	6111	SG09-T6	260	315	16	✓		High-strength alloy for structural purposes Stress corrosion cracking resistance: Good
	6005C	6N01-T5	260	220	12		✓	High-strength alloy for extrusion Hollow extrusion performance: Good
	6061	6061-T6	315	275	19		✓	High-strength alloy for extrusion Hollow extrusion performance: Good
	6061	661S/CM61-T6	340	300	18		✓	High-strength alloy for extrusion Hollow extrusion performance: Good
		SG109-T6	310	270	14		✓	High-strength alloy for extrusion Hollow extrusion performance: Good
		GS310-T6	390	365	19		✓	High-strength alloy for extrusion Hollow extrusion performance: Good
	6061	6061-T6	315	275	19		✓	High-strength alloy for forging. Forgeability and corrosion resistance: Excellent; Machinability: Good
	6082	6082-T6	325	300	18		✓	High-strength alloy for forging. Forgeability and corrosion resistance: Excellent; Machinability: Good
		SG210-T6	400	360	18		✓	High-strength alloy for forging. Forgeability and corrosion resistance: Excellent; Machinability: Good
7000 Al-Zn-Mg	7003	ZK141-T7	360	280	16	✓		High-strength alloy for structural purposes Shear strength: 190N/mm²
	7075	75S-T6	570	510	11	✓		High-strength alloy for structural purposes Shear strength: 330N/mm²
	7003	7003-T5	310	260	16		✓	High-strength alloy for extrusion Hollow extrusion performance: Good
	7204	7N01-T5	360	320	14		✓	High-strength alloy for extrusion Hollow extrusion performance: Good
	7204	K70Y-T5	415	360	16		✓	High-strength alloy for extrusion Hollow extrusion performance: Good
		ZK55-T6	420	380	14		✓	High-strength alloy for extrusion Hollow extrusion performance: Good
	7046	ZK170-T6	450	420	14		✓	High-strength alloy for extrusion Hollow extrusion performance: Good
		ZK80-T6	500	470	14		✓	High-strength alloy for extrusion Hollow extrusion performance: Good
	7075	7075-T6	590	540	14		✓	High-strength alloy for extrusion
	7050	7050/ZG62-T6	620	570	13		✓	High-strength alloy for extrusion
		ZC80-T6	630	580	13		✓	High-strength alloy for extrusion
		ZC88-T6	650	600	13		✓	High-strength alloy for extrusion

UACJ's next-generation aluminum technology

At the UACJ Research & Development Division, comprehensive developments on automobile materials, including aluminum alloy materials, optimization of surface treatment and processing are being carried out.

Corporate Name	UACJ Corporation
Headquarters	Tokyo Sankei Bldg., 1-7-2 Otemachi, Chiyoda-ku, Tokyo 100-0004, Japan
Principal Business	Manufacture and sales of aluminum rolled products, extrusions, cast products, forged products, precision-machined components and copper tubing.
Capital	52,277 million yen (approx 463 million U.S. dollars)

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