English Version

ATZ

ATZ spezial Motor Fan illustrated

Special Edition

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

Discover Aluminum in the Age of electrification

Special Feature **Aluminum Technology 9**

ALUMINUM

Smart Developments

Discovering Aluminum in the Age of Electric Vehicles

The leading lightweight material for automobiles.

The automotive industry is undergoing a period of major change, including a shift to electric vehicles with the aim of reducing CO_2 emissions and building a sustainable society. The key to this mission is the reduction of car body weight. Aluminum is not only lightweight, but also has excellent impact energy absorption properties, which results in improved crash safety. Lighter vehicle bodies will lead to the downsizing of key components such as powertrains, batteries, and brakes, creating a virtuous cycle that will increase cruising range.

As new technologies such as electric powertrains and skateboard architecture are being introduced, aluminum's features of superior formability, weldability, and surface treatability as a structural material for automotive applications are being widely utilized. Furthermore, its excellent heat transfer and electrical properties contribute to the thermal management of batteries. Aluminum can be recycled many times, requiring only a fraction of the energy required for recycling compared to primary aluminum production.

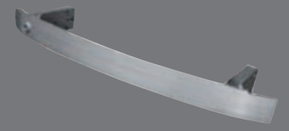
In the face of rising global energy prices, recycled aluminum saves energy and reduces environmental impact. Aluminum alloys play an important role in the manufacture of automotive components, and their properties are constantly being refined through improvements in material development and manufacturing process technology. An environmentally friendly metal, aluminum continues to evolve as a more reliable lightweight material that contributes to the realization of a sustainable mobility society.

Superior properties of aluminum

- Lightweight
- High strength
- Surface treatability
- Recyclability
- Corrosion resistance
- Machinability
- Low-temperature toughness
- Non-magnetizabl
- Reflects light and heat
- Non-toxicity
- Thermal conductivity
- Conductivity
- Suitable for casting
- Weldability
- Vacuum properties

> Aluminum sheet material

Aluminum has a specific gravity of 2.7, about one-third less than steel. It's widely used as a structural material for vehicles because of its high strength and excellent formability, corrosion resistance, and recyclability. Even in car models that achieve weight reduction through a multi-material body structure that uses aluminum alloy sheets, high-tensile steel sheets, CFRP, and other materials, aluminum is favored for the hood outer panels, fenders, door panels and other parts. Aluminum alloys are also used as a key concept to "enhance the value of the car".

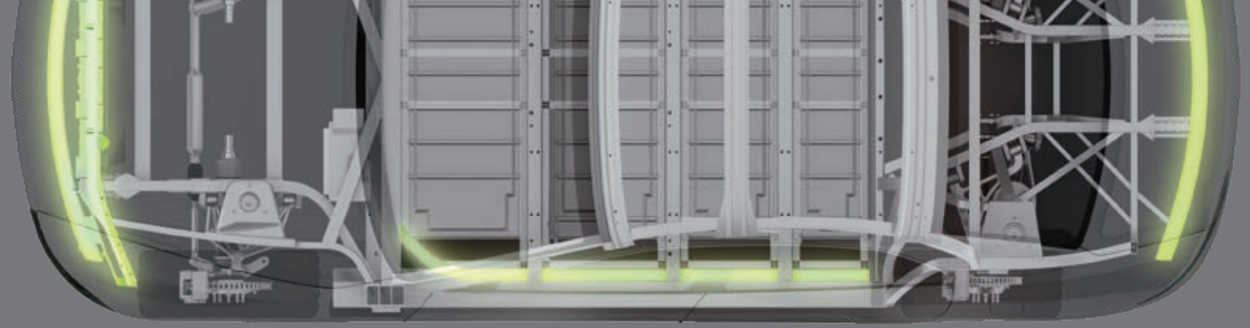


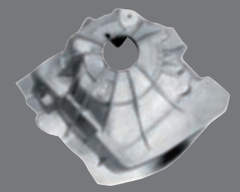
> Aluminum Extruded Shapes

Aluminum extruded shapes, manufactured through precision extrusion processes, can form complex cross-sectional shapes, making them ideal for bumper beams, chassis structural materials, and other parts with long, uniform cross-sections. Many large SUVs use extruded aluminum space frame structures to improve body rigidity and lower the center of gravity. There is also wide use of aluminum extruded shapes with relatively simple cross-sectional shapes for structural members such as subframes, beams, and braces.

> Forged Aluminum

Aluminum forgings made by the forging process increase strength and toughness to a level comparable to those of steel. Aluminum forgings are widely used in important safety components such as suspension arms, brake calipers, and other parts. In hot forging, aluminum material is heated to approx. 300°C to 480 °C and pressure is applied to achieve high strength and toughness. As a result, brake calipers achieve excellent braking performance and durability to withstand braking exposed to high temperature and pressure, and suspension arms achieve stable suspension and driving performance.





> Cast Aluminum

Aluminum castings are widely used in powertrains, especially for cylinder blocks and transmission cases.
Castings can be easily ribbed to reduce the number of unnecessary parts while ensuring rigidity and strength to meet the functional requirements of the part.
Due to its ability to easily achieve complex shapes and internal structures, cast aluminum is suitable for various applications, including suspension towers, cross members, side members, and other connecting parts, as well as body-to-chassis connections.

Multi-material Monocoque Body

› Tesla **Model-Y**

The greatest feature of the Tesla Model Y is the structure of the rear section. It's composed of a large underbody made of aluminum alloy for die-casting innovative structural parts, produced by "gigacasting" using a huge die-casting machine.

Multi-material monocoque body

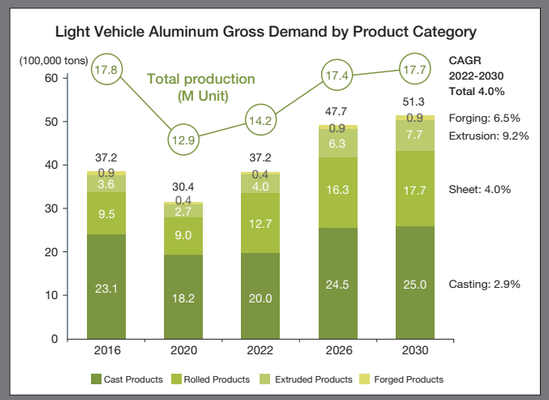
› BMW **7series**

The BMW 7 Series have a multi-material body structure that employs aluminum alloys, high-tensile steel, CFRP, and other materials to achieve an overall body weight reduction of approx. 130 kg compared to the previous 7 Series models.

All-aluminum monocoque body

› JAGUAR **XE**

Jaguar has a deep knowledge of aluminum body production. The latest XE, the first Jaguar & Land Rover common platform, uses an all-aluminum alloy monocoque, mainly based on the well structure of the floor.



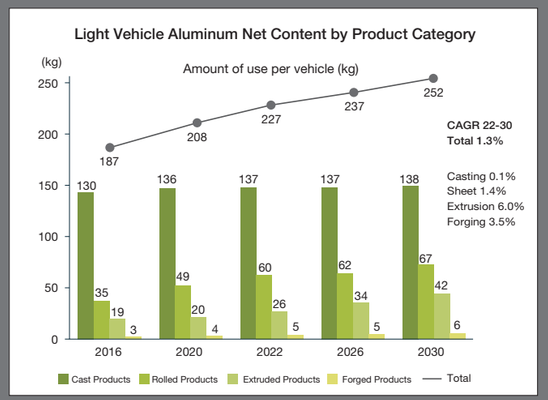


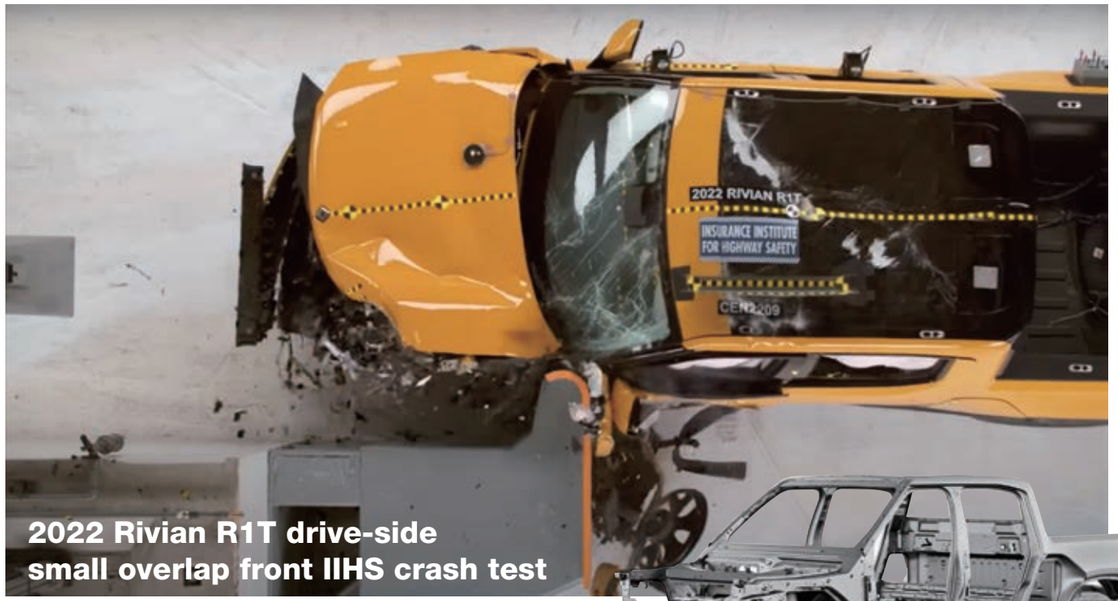
Photo: IIHS (front cover), Tesla, BMW, Jaguar, AA & Ducker

Source：Aluminum Association Drive Aluminum "Light Vehicle Aluminum Content and Outlook Study"
2022 Study summary report - Ducker Holding LLC

Motor Fan illustrated | ALUMINUM AUTOMOBILE TECHNOLOGY

Evolving Aluminum EV Platforms for the Future

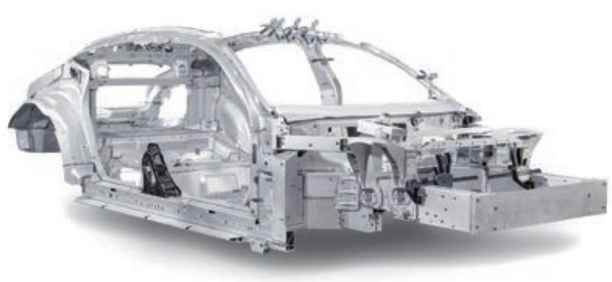
Assessments of vehicle safety are conducted separately in each country and region, including NHTSA (U.S. Department of Transportation), IIHS (U.S.A.), and EURO NCAP (Europe). EURO NCAP has updated its test contents and methods: the new test is more rigorous in that a "moving barrier" dolly collides head-on with the test vehicle. This frontal collision test not only evaluates the protection performance of the occupants inside the vehicle, but also how the structure of the front end of the vehicle affects the injuries of the collision partner. At the same time, the collision speed and mass of the moving barrier in the side collision test has been increased. Starting in 2023, utilizing new standards that employ heavier barriers traveling at higher speeds, the IIHS is conducting preventive performance tests and side impact tests that more closely mimic the damage that SUVs actually cause.



2022 Rivian R1T drive-side small overlap front IIHS crash test

The skateboard platform and body common to Rivian Automotive's R1T electric pickup truck and R1S electric SUV is a multi-material construction of aluminum alloy, high-strength steel, and CFRP.

Polestar 5 Next-Generation Bonded Aluminum Unibody

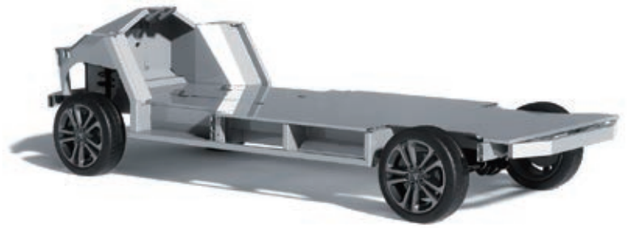


Polestar's bonded aluminum unibody technology eliminates the 4,000 rivets typically used in previous processes to join multi-material structures and aluminum components. Instead, it uses adhesives and oven curing to create a one-piece construction. While this has significant advantages, it is also labor-intensive and is difficult to scale up without sacrificing quality. The unibody technology of the Polestar 5, achieved by combining the platform and body, is expected to significantly reduce vehicle weight and enhance range and responsiveness, while maintaining the highest safety standards.

Polestar 2 CMA Platform

In the first EURO NCAP tests of 2021, the Polestar 2 was awarded the highest five-star safety rating. The platform is equipped with aluminum alloy impact absorbers called the Front Lower Load Path (FLLP) and Severe Partial Offset Collision (SPOC) systems to enhance the function of the front side crushable zone in the event of a frontal collision. The highest level of safety is achieved by preventing wheels and other objects from entering the interior, while at the same time mitigating the impact on the occupants. The battery housing is constructed of three layers of aluminum extruded shapes with hollow cross-sections, titanium plates, and aluminum extruded shapes without hollow cross-sections.

New eCV1 EV Platform for Commercial Vehicles



Watt Electric Vehicle Company of the UK has developed a new all-aluminum alloy EV platform, the eCV1, for 3.5-ton class commercial vehicles. The eCV1 is based on Watt's PACES platform and consists of a chassis and driver cab. The new architecture uses the “cell-to-chassis” (CTC) method, similar to Tesla's latest approach for batteries, whereby the battery pack becomes a structural element of the chassis to optimize body rigidity, reduce weight, and maximize payload capacity. It’s an all-aluminum platform that supports a center seat for the driver and seating for one to three passengers.

Next-generation mobility for 50 years of use　Extruded aluminum alloy frame

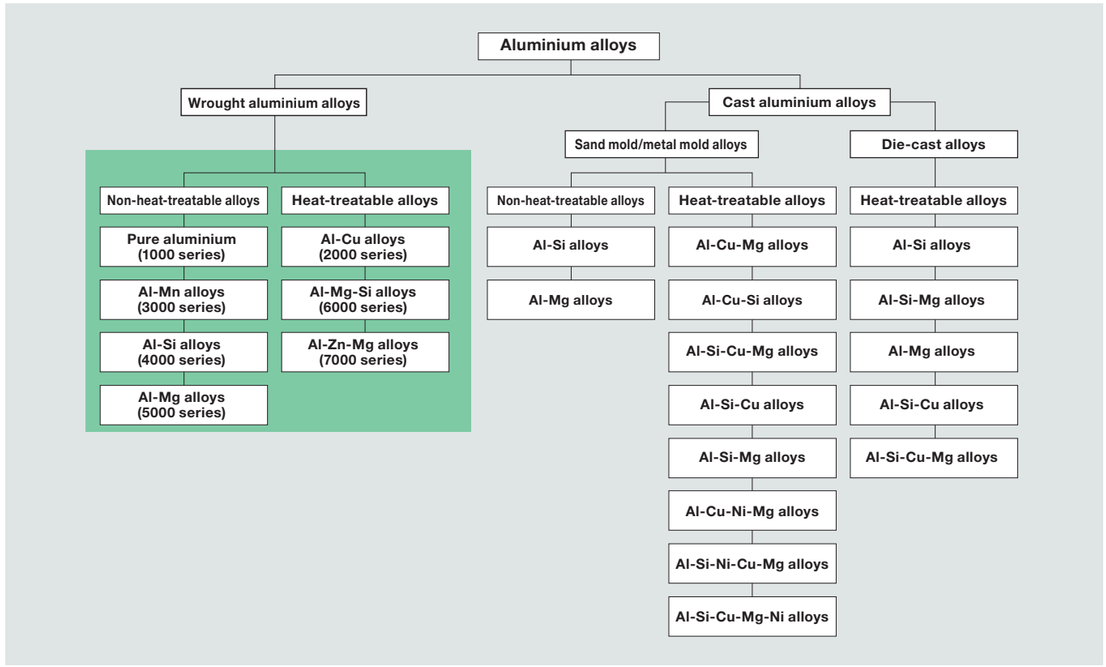
The German “RWTH Aachen” and the German startup “e.Volution” have developed a circular economy electric vehicle based on a frame made of aluminum alloy extrusion profiles that can be used for 50 years. By using an aluminum extruded shape frame as a base, the company can more cost-effectively produce small-quantity, high-mix vehicles. Almost all components of the vehicle, including batteries, headlights, displays, vehicle computer, exterior, seats, and interior, can be replaced in a “re-assembly plant”, and vehicle refurbishment work and upgrades can be performed cyclically every five years.

Photo: IIHS, Rivian, Polestar, Watt Electric, e.Volution/RWTH Aachen

>> Lightweight and Sustainable Material for Future eMobility

Discovering Aluminum in the Age of Electrification 1

The various properties of aluminum alloys vary greatly depending on the type and quantity of added elements. Aluminum alloys are broadly classified into “wrought alloys” and “cast alloys”. Within each category, they are further divided into “heat-treatable alloys”, in which the properties of the material are adjusted by heat treatment, and “non-heat-treatable alloys”, in which no heat treatment is performed.
Wrought alloys are classified into alloy series ranging from the 1000 series pure aluminum to the 7000 series. They are indicated by a thousandth digit according to the type of added elements. Expanded materials are those processed into various shapes, such as sheets and foils by rolling, and shapes, tubes, rods by extrusion, and forgings are also included in these materials.
Cast aluminum alloys are classified into two systems: alloys for molding and for die-casting. Wrought aluminum alloys are used differently depending on the intended purpose of use. The AA (American Aluminum Association) indicates the material by its four-digit number.



General properties & applications of aluminum alloys

1000 Series

The 1000 series is an industrial pure aluminum material with an aluminum composition of 99.00% or higher. 1100 and 1200 are typical alloys. The names 1050, 1070, and 1085 indicate that their aluminum purity is 99.50%, 99.70%, and 99.85% or higher pure aluminum respectively. The 1000 series has low material strength, but excellent corrosion resistance, workability, and surface treatment properties. 1060 and 1070 have excellent electrical and thermal conductivity, and they are used for power transmission and distribution equipment and for heat-dissipating parts.

2000 Series

Al-Cu heat-treated alloys are represented by 2017 and 2024, known respectively as “duralumin” and “super duralumin”. They feature excellent strength and good machinability comparable to steel. Free-machining alloys such as 2011 are widely used for transportation equipment and machine parts. 2014 is a representative alloy for forging materials, and is used for structural materials as well as vehicle and automobile components due to its high strength and relatively good formability.

3000 Series

The Al-Mn non-heat-treatable alloys 3003 and 3004 are representatives of this series. The addition of Mn increases strength by 10-20% compared to the 1000 Series alloys, and they also have excellent deep drawability. They are widely used in the fields of vessels, construction materials, containers, and offset printing plates. 3004 and 3104 are alloys in which about 1% Mg is added equivalent to 3003 to further increase strength. In addition, 3003 and 3004 are often used as cladding material for heat exchangers.

4000 Series

4032 and 4043 are typical non-heat-treatable Al-Si alloys. 4032 is an alloy in which the addition of Si suppresses thermal expansion and improves wear resistance, while the addition of Cu, Ni, and Mg improves heat resistance. 4043 is a typical welding material containing 5% Si. It’s suitable for welding Al-Mg-Si alloys and aluminum castings because of its low melting temperature and high resistance to high-temperature cracking of the metal to be welded. It’s used for welding wire, welding rods, and brazing sheets.

5000 Series

Al-Mg non heat-treatable alloys with Mg content of 0.4% to 5% have excellent corrosion resistance and surface treatability. The 5110 alloy with low Mg content is used for decorative materials and vessels, and 5005 for vehicle interiors. The medium-strength 5052 alloy with Mg content of about 2.5% is a general-purpose 5000 Series alloy. The 5083 alloy is considered a welded structural alloy, featuring the highest strength among non-heat-treatable alloys as well as excellent weldability, seawater resistance, and low-temperature properties.

6000 Series

Al-Mg-Si heat-treatable alloys have excellent strength, corrosion resistance, and surface treatment properties. 6061 and 6063 are representative structural materials. 6061 is a sheet material with a trace amount of Cu added to increase strength. In particular, 6063 is a representative alloy for aluminum extruded shapes and is used for building sashes, automobile components, and electrical products. Alloys of this series are also increasingly being used for automobile body panels.

7000 Series

The 7000 Series can be classified into the Al-Zn-Mg-Cu alloys, which have the highest strength among aluminum alloys, and the Al-Zn-Mg alloys for welded structures that do not contain Cu and are used for parts requiring high strength and weight reduction. 7075 is a typical heat-treated Al-Zn-Mg-Cu alloy called super duralumin. 7204 is a typical heat-treated Al-Zn-Mg alloy for welded structures. It’s used in railroad cars and land structures because of its high strength and excellent joint efficiency.

All-aluminum monocoque body

› FORD **F-150 Lightning**

The core model of Ford's large pickup trucks has garnered much attention due to its all-aluminum body. The F-150 Lightning is the electric model.

All aluminum alloy platform

› TESLA **MODEL-S**

The Model-S has an all-aluminum platform that utilizes aluminum materials extensively to achieve a low center of gravity and excellent driving performance.

All-aluminum monocoque body

› JAGUAR **I-PACE**

Jaguar's first battery-electric vehicle uses a strong and rigid lightweight all-aluminum unibody structure with riveting and bonding technologies to reduce body weight.

All-aluminum monocoque body

› Range Rover **Sport**

This large, heavy SUV is the first to incorporate an aluminum-specific body design, achieving both a highly rigid body and a lightweight design.

All-aluminum alloy space frame

› Audi **Q7**

The Q7 has a body structure that leverages its strength in aluminum alloys. Aluminum extruded shapes are used for the front side members and bumper.

All-aluminum monocoque body

› RENAULT **ALPINE A110**

The Alpine A110 is a lightweight sports car from the legendary Alpine brand, featuring an all-aluminum alloy platform and upper body structure. It weighs an ultra-light 1,103 kg.

Photo: Ford, Tesla, Jaguar, Jaguar Land Rover, Audi, Alpine

>> Lightweight and Sustainable Material for Future eMobility

Discovering Aluminum in the Age of Electrification 2

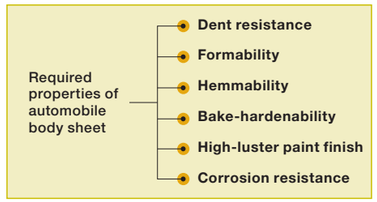
Aluminum Alloy Sheet

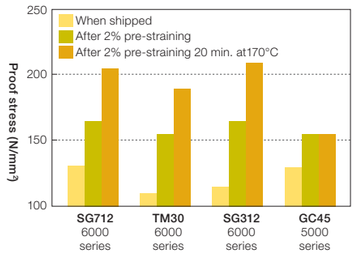
Contribute to the value of the vehicles

Due to their light weight and strength, aluminum alloy sheets play an important role in reducing component size, improving power performance, and extending cruising range. In addition, reducing the weight of the vehicle body can create a virtuous “angel cycle”, in which key components such as the powertrain, battery, and brakes can also be downsized.

Today, “closed-loop recycling” of aluminum alloy sheets is progressing in various regions. Aluminum is highly recyclable, and recycling saves more than 90% of the energy needed to manufacture new products. Aluminum alloy not only reduces the weight and environmental impact of vehicles, but also increase their value.

The 6000 series heat-treatable ternary alloy has a property called “bake-hardness” (=paint baking hardenability), which increases strength by heating during paint baking. As a material with low strength and excellent formability during the forming process and high strength after paint baking, it has become the mainstream aluminum alloy for car body panels.





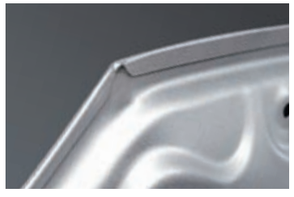
Change in proof stress of body sheets
(Source: UACJ Corporation)

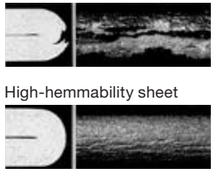
Lexus LS500 Door Panel (Inner & Outer)

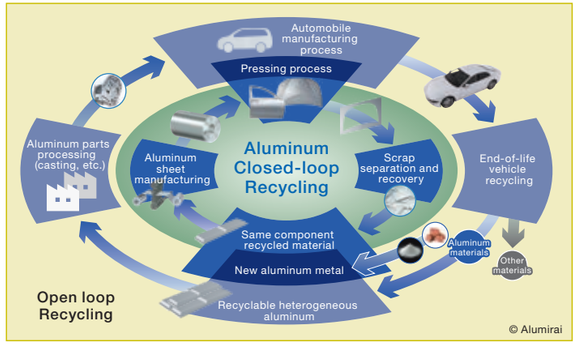
LEXUS LS door from the side, the depth of the aperture in the inner panel can be clearly seen. The 6000 series alloys are used for both the inner and outer panels to achieve integrated molding.

Hemming

The outer and inner panels of the hood are joined by a process called “hemming”, in which the edges of the outer panel are bent inward and pressed together with the edges of the formed inner panel. Aluminum material has lower elongation than steel plate, and thus is prone to cracking at the outer panel bends when hemming is performed.







Closed-loop recycling of body panels

Aluminum “closed-loop recycling” is gaining attention as manufacturers worldwide strive for carbon-neutral automotive manufacturing, with activities underway at their production facilities to conserve critical resources and locally recycle raw materials. The quality of aluminum is not degraded by recycling, so it is particularly suited to the environmentally friendly closed-loop process, which can significantly reduce energy consumption and thus increase sustainability throughout the supply chain.

Photo: Toyota, UACJ, Chevrolet, Honda, Mercedes-Benz, Volkswagen

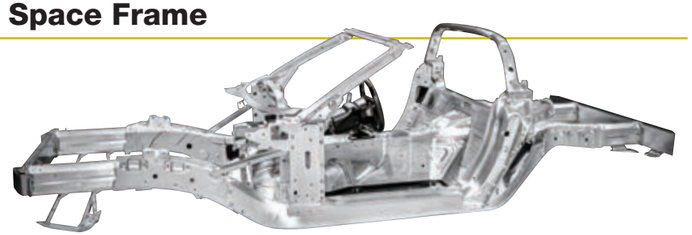
Aluminum Extruded Shapes

For Lightweight Car Body Structures

Aluminum extrusion is a process that can produce long products with complex cross-sections, hollow cross-sections, and complex shapes with higher precision than other methods. In this process, cylindrical aluminum alloy material (“billet”) is heated to high temperatures (400-500°C) and then extruded under high pressure on to dies of various shapes. This enables continuous production of products with the required cross-sectional shapes. The extruded aluminum shapes protect occupants and critical structural components by absorbing and effectively dispersing and mitigating external impact energy.

Aluminum Extruded Shape Space Frame

The body of the Chevy Corvette C7 uses an extruded aluminum spaceframe structure. The frame achieves a 50:50 weight balance between the front and rear and is 45 kg lighter than the previous model, yet 57% stiffer and stronger. These features dramatically improve collision safety, handling, and cornering performance.



Space Frame Using Composite Materials

The Honda NSX is a space frame structure made of multiple materials, including aluminum alloy, ultra-high-tensile steel, and resin. However, the space frame structure is primarily made of high-strength extruded aluminum shapes, with aluminum materials accounting for about 79%, steel 13.5%, and resin 7.4%. The front and rear crushable zones are made of extruded aluminum beams, and ablation-cast aluminum members are used for their joints.

EV battery housings made of aluminum extruded shapes

Aluminum extruded shapes are used for the EV battery housings in many EVs to protect the battery cells from shocks and vibrations and provide efficient heat conductivity to dissipate the generated heat. (Photo: Mercedes EQC)

The battery housing of the Volkswagen ID.4 houses the crash frame and cooling systems, completing the battery module for the MEB platform. Aluminum extruded shapes are used for battery protection in the event of a crash.

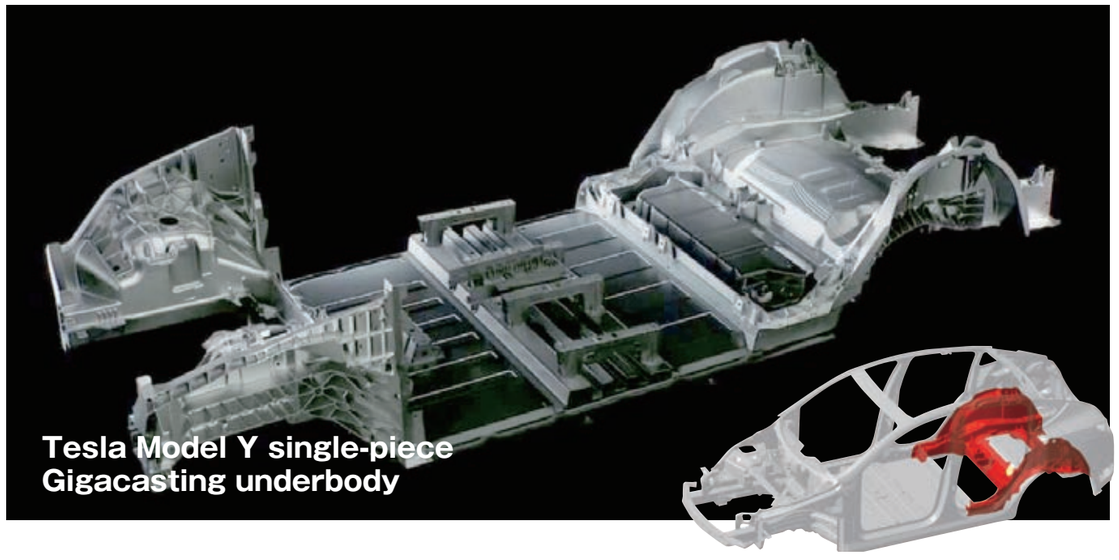
>> Lightweight and Sustainable Material for Future eMobility

Discovering Aluminum in the Age of Electrification 3

Aluminum die-cast products

The Next-Generation Chassis Structures

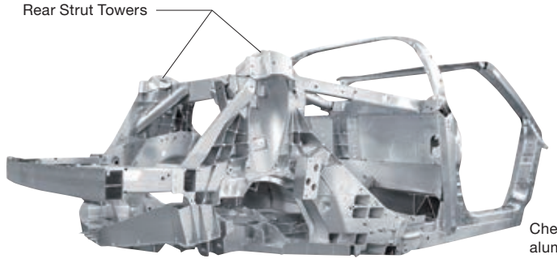
The use of large aluminum die-cast products for vehicle body structures has been attracting attention for EV body designs. Tesla manufactures the rear underbody using a giant die-casting machine called a "Giga Press", which can integrally form car body parts. Aluminum die-cast parts can be formed into complex shapes, making them suitable where both light weight and strength are required. The use of large aluminum die-cast parts in car body structures enables the integration of conventional structural members, reducing the number of parts and welding and other joining operations. In the manufacturing process of aluminum die-cast parts, aluminum alloy is first melted at a high temperature of about 660°C and injected into a die-casting machine. The injected molten metal is filled into the die at high speed and high pressure, and solidifies in the die through cooling to form the desired aluminum part shape. The part is then removed from the mold, and surface treatment or fabrication is applied as necessary to complete the process.

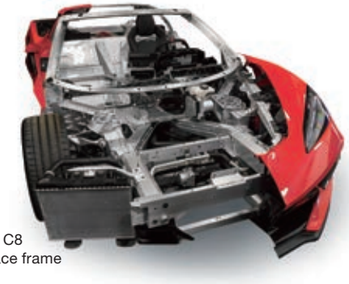


Chassis structure using extruded shapes and “gigacasting”

Tesla has switched underbody production to an aluminum die-casting process, enabling the integrated production of rear frames for the Model Y and other models, replacing 171 parts and 1,600 welding operations of the previous structure with two large parts.

The Chevrolet Corvette C8 uses six large die-cast aluminum parts for the strut towers and other parts. The space frame is made by combining and joining high-strength aluminum alloy. The material ratio is 40% extruded shapes, 39% sheets, 18% die-cast products, and 3% other materials.





Chevrolet Corvette C8
aluminum alloy space frame

Photo: Tesla, GM, UACJ, Endless

Aluminum forgings

Reliability for Safety-Critical Automotive Parts

Lightweight yet possessing excellent strength properties, aluminum forgings provide reliability for safety-critical automotive parts. The forging process can produce parts with complex shapes, enhancing their strength and durability. Aluminum forged suspensions contribute to stabilizing the vehicle and improving ride and handling. Moreover, aluminum forged brake calipers enhance high-speed braking performance, simultaneously reducing unsprung weight, leading to improved vehicle dynamics. This effect can be expected to have a significant impact on fuel and electricity costs. Aluminum forgings primarily use heat-treatable aluminum alloys among the various aluminum alloys. These alloys are widely employed for automotive structural materials due to their high strength and durability, achieved through crystal grain refinement and crystal orientation during forging and heat treatment. In contrast, aluminum alloys for casting typically exhibit a coarser crystal structure and lower strength due to rapid cooling and solidification after being melted and injected into a mold.

Manufacturing Process of Die Forging

Aluminum alloys used in forging are selected according to product requirements and applications, taking into consideration characteristics such as strength, toughness, and heat resistance. In hot forging using a die, aluminum alloy is heated to around 400°C, then set in the die of a forging press, and formed into a predetermined shape. This heating, forging, and T6 treatment (=age hardening treatment) optimizes the crystal structure and grain refinement of the aluminum alloy to improve strength, hardness, and fatigue properties. In the finishing process, the forged product is machined using CNC machining or other equipment to achieve the final shapes.

Forged aluminum alloy brake calipers

Forged brake calipers made of high-temperature, high-strength aluminum alloy manufactured by UACJ… Endless brand brake systems are highly regarded for their durability and reliability by domestic and international racing professionals, and the use of lightweight, high-rigidity forged aluminum parts is expanding due to the increasing size and performance of vehicle bodies, such as EVs and SUVs. Aluminum alloys for forging have been developed to meet required properties such as high strength, high wear resistance, and high-temperature strength, in addition to forgeability.

Breaking endurance test status: Endless Advance Co.,Ltd.

>> Lightweight and Sustainable Material for Future eMobility

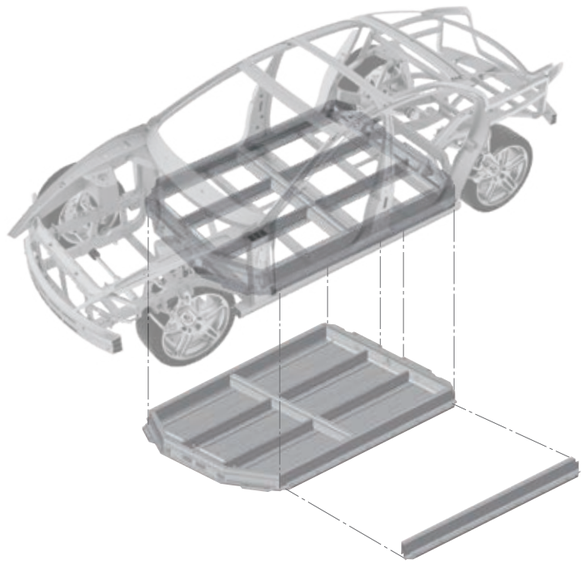
Discovering Aluminum in the Age of Electrification 4

Aluminum Components Development in the Field

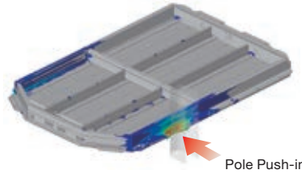
UACJ Corporation

The development of aluminum automotive components is an ongoing effort to create efficient and safe next-generation components encompassing a wide range of factors, such as weight reduction, electrification, automated driving, safety improvement, digitalization, and sustainability. There is a focus on reducing emissions, utilizing renewable energy, and reducing the recyclability and waste of components. UACJ's automotive component development is based on benchmarking and agile development to flexibly respond to customer requirements.

UACJ Corporation, one of the world's leading aluminum manufacturers, established the Mobility Technology Center (MTC) in 2020. It features an integrated system that covers technical planning, materials development, product development, and production technology development. The evaluation and elemental technologies are based on the specialized capabilities of materials and the comprehensive capabilities of materials development, in cooperation with UACJ's R&D Center.

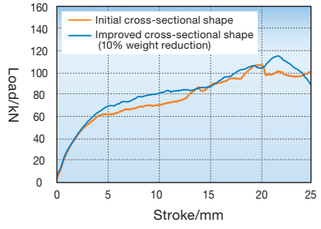


• **Enclosure level analysis**



• **Partial model analysis**

• **Energy absorption (EA) improvement results**



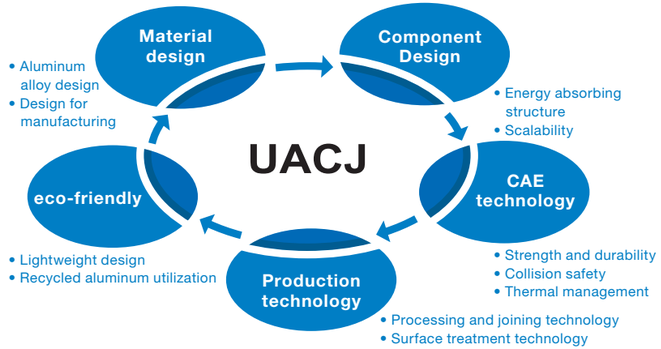
UACJ Mobility Technology Center Activities

Interviewer (MFi): I hear that aluminum components are being used in battery housings for electric vehicles.
Dr. Niikura: Extruded shapes of aluminum alloy are widely used in the battery housings of today's mainstream electric vehicles. These aluminum structural members perform an important role in terms of safety and battery temperature control. In particular, during a vehicle side impact, the cross-sectional profile of the aluminum extrusions, with a primarily hollow cross-section, absorbs impact energy by deforming under the impact load.
MFi: How do you enhance absorption performance of collision energy?
Niikura: In a side impact of a battery housing, it's difficult to distribute the side impact loads to other structural members, so the side frames of the battery housing must absorb the impact energy. Therefore, it's important to reduce the weight of the battery housing while satisfying the required impact absorption performance. As a method to achieve this, we have established simulation technology of impact energy absorption based on UACJ's proprietary know-how, and are developing aluminum structural members.

Vice-Director of Mobility Technology Center
Marketing & Technology Division
UACJ Corporation

Akio Niikura, Ph.D.

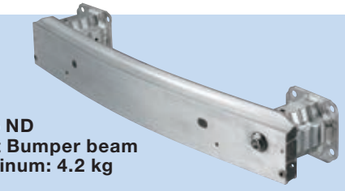
MFi: How will MTC's components development develop in the future?
Niikura: UACJ has jointly developed bumper beams, crash boxes, and side frames of battery housing, which are typical shock-absorbing components for crushable zones, and has accumulated technical information by manufacturing them at domestic and global manufacturing bases. In the future, we would like to promote the modularization of structural members using extruded profiles of aluminum alloy for crushable zones. In parallel, we have also been developing thermal management systems such as cooling channels for battery coolers. We would like to further enhance the manufacturing technology based on UACJ's unique know-how to meet the demand for the development and manufacture of aluminum components for the scalable platforms promoted by automobile manufacturers.



UACJ's Global Expansion

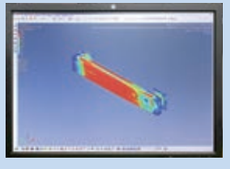
UACJ corporation is jointly developing and producing bumpers and basic impact-absorbing components with automobile manufacturing companies on a global basis. Companies have long developed aluminum materials suitable for various parts of vehicles, and are also focusing on the development of manufacturing processes for aluminum components to reduce environmental impact in the automotive industry.

UACJ's U.S. subsidiary, Michigan-based UACJ Automotive Whitehall Industries, Inc. (UWH), has been developing and supplying many of UACJ's aluminum structural components to emerging EV manufacturers since their early days. UWH has expanded its aluminum extrusion presses at its main plant in Michigan and built a new plant for automotive components in Arizona.



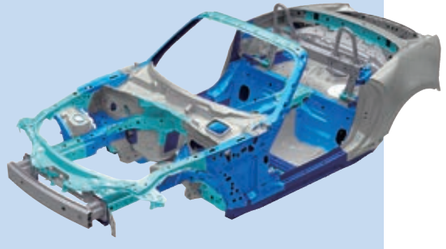
MX-5 ND
Front Bumper beam
Aluminum: 4.2 kg

MX-5 NC
Front Bumper beam
Steel: 5.8 kg



Mainstream lightweight sports car, Mazda MX-5 Development of aluminum alloy bumper Reinforcement components

The Mazda MX-5 produces many components made of aluminum alloys. This bumper was jointly developed by Mazda and UACJ. The front bumper is the furthest structure from the vehicle's center of gravity. Reducing its weight improves fuel economy and enhances driving performance. Mazda's solution was to apply a 7000 series high-strength aluminum alloy. After a comprehensive review, including the manufacturing method, Mazda and UACJ succeeded in fully leveraging the advantages of aluminum by producing a bumper approx. 30% lighter than the previous one.



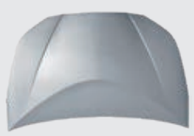
>> Lightweight and Sustainable Material for Future eMobility

Photo: UACJ, Alumirai, Mazda, MFi

Guidelines for Automotive Aluminum Alloy Applications

Alloy designation: "AA" means the designations used by the Aluminum Association.

Series	Alloy designation AA	Alloy designation UACJ	Characteristics	Use in automobiles
1000	1050	A50	Excellent processability and surface treatability. The most corrosion-resistant of all aluminum alloys.	Heat insulators
	1100	A30	General-purpose aluminum with over 99.0% purity. Surface appears slightly white after anodizing.	Heat insulators, License plates
	1200	A0		Heat insulators
2000	2014	14S	Very strong alloy used for structural components. Because of relatively higher copper content, inferior corrosion resistance.	Motorbike handles, ABS
	2017	17S		Shock absorbers, Steering wheel, Spokes, Conrods
	2024	24S		
	2219	B19S	High-strength, excellent properties at high and low temperatures, superior weldability, but inferior corrosion resistance.	Air conditioner rotors
	2618	2618	High-strength at high temperatures. Saitable for forging and machining.	Turbocharger compressor wheels, Pistons
		CG29 20A1	Higher strength at elevated temperatures than that of 2618.	Engine Parts (conrods, pistons)
		CB156 CB256 KS26	Lead-free highly-machinable alloys.	Transmission AT-Valves
3000	3003	303S D3S	10% stronger than 1100. Good processability and corrosion resistance.	Piping and Tubing
	3004	304S 4S	Stronger than 3003. Excellent deep-drawability, and good corrosion resistance.	Cowl grilles, Heat insulators
4000	4032	32S	Excellent heat and abrasion resistance. Low thermal expansion coefficient.	Engine Parts (pistons)
		SC100	Excellent abrasion resistance and forgability. Stronger than 4032.	Power steering housing, Valve lifters Compressor scroll for air conditioner
		SC300	A stronger version of SC100.	
		TF06B TF08 TF10B	Excellent abrasion resistance and forgability. Stronger than 4032.	
		TF12B	A hypereutectic alloy with enhanced forgability.	Compressor rotors
5000	5052	52S	A medium-strength alloy. Good corrosion resistance and formability. High fatigue strength.	Meter display panels, AT drums, Air bag inflators, Covers
	5454	D54S	20% stronger than 5052. Good corrosion resistance.	Wheel rims, Suspension components, Oil pans
	5083	183S	An alloy for use in welded structures. The strongest of the non-thermally treated alloys.	Tanks, Gas cylinders Body panels (super plastic forming)
		383S	A high formability version of 183S. Excellent superplastic properties.	
		483S NP5/6	An extrusion alloy version of 183S.	Lashing rails
	5182	A82S	Nearly as strong as 5083. Good processability and corrosion resistance.	Dust covers, seat frames, air cleaner cases, spring sheets
		GM145	Good formability and stress corrosion cracking performance.	Body panels (interior), Heat insulators
		GM47	Stronger than 383S and GM145 and superior in superplastic forming	Body panels (super plastic forming)
	5154	A154S	20% stronger than 5052. Good formability.	Wheels, Underbody components, Drivetrain components, Suspension components
		A254S	20% stronger than 5052. Good stress corrosion cracking performance.	
		GC32	Good formability and stress corrosion cracking performance.	
5000	5022	GC45	High-strength, high-formability body panel material. Low coat-baking proof stress reduction.	Body panels (Outer/Inner), Heat insulators
	5056	356S	A non-heat-treatable alloy for welded structures. Excellent seawater resistance.	Brake pistons, Fuel delivery pipes, Airbag inflators
6000		SG712	Body panel alloy with high bake hardenability, formability, and high-hemmability.	Body panels (Outer/Inner)
		TM30	BH type body panel alloy. lower strength than alloy SG712, but superior in bend formability	
		SG312	BH type body panel alloy. Even stronger than SG712 with good formability.	Body panels (Inner)
		SM28	BH type body panel alloy. Low-CO_2 Recycled Alloys Utilizing Aluminum Scrap	
	6063	63S 163S Y63	Typical extrusion alloys. Lower strength than 6061, but superior extrusion properties.	Moldings, Seat frames, Truck bed gates, Roof railings, Piping, Crash box
	6005C	465S L55	Intermediate strength between 6061 and 6063. Good corrosion resistance and weldability.	Side sills, Space frames, Engine brackets, Seat frames, ABS, Side sills, Shock absorbers
	6061	61S 161S	Heat-treatable alloys with good corrosion resistance.	ABS, Metal fittings, Wheels, shafts, Arms, Links, Air bags, Joists, Receiver tanks, Bumper reinforcement, Instrument panel beams, Battery components
		561S		Power plant frames
		SG109	High-strength alloy with good bendability and corrosion resistance. Hollow extrusion is possible.	Bumper reinforcement, Space frames
	6082	SG10 SG710	Equivalent or superior strength to 6061, good corrosion resistance	Arms, Links, Space frames, Bumper reinforcement
	6110		Aluminum alloy with even higher strength than 6082	Bumper reinforcement
		SG210 SG310	Aluminum alloy for high-strength forging	Suspension arms, Wheels
		GT209 KS69S	Lead-free high-machinability alloy.	AT valves
7000	7003	ZK60 K73	An extrusion alloy for welded structures. Better extrusion properties than 7204.	Bumper reinforcement, Seat sliders, Door impact beams
	7204	K70 ZK147 K70Y	Alloys for welded structures. The strength at the welded part recovers almost to the same as that of the raw material by natural aging.	Jacks, Steering components, Crossmembers, Steering wheel core metals, Brake pedals, Bumper reinforcement, Motorbike frames
		ZK55	Even stronger than 7204. Welding and hollow extrusion is possible.	Bumper reinforcement, Impact beams, Motorbike frames and rims
	7046	ZK170		
		ZK80	Highest strength aluminum alloy for hollow extrusion. Non-Weldable	Motorbike rims
	7075	75S	Typical high-strength alloy for use in aircraft manufacture.	Seatbelt hinges, Links, Bobbins, Retractors
		ZC88	High-strength aluminum alloys.	Motorbike front forks



Hood (Outer/Inner)

Door (Outer/Inner)

Rooftop

Freestyle door

Bumper Reinforce

Brake caliper

Subframe

Suspension arms

Source: UACJ Corporation Photo: UACJ, Endless

>> Lightweight and Sustainable Material for Future eMobility

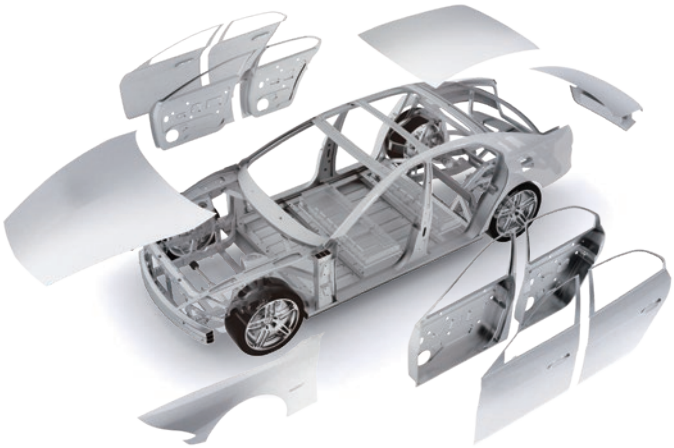
UACJ

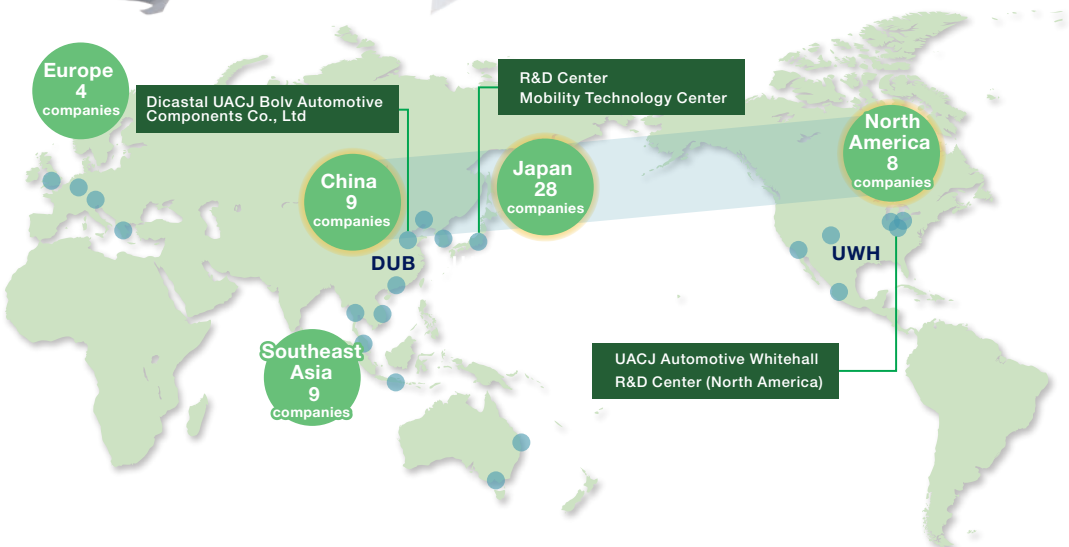
eMobility Technology
Sustainable Aluminum
for Future Mobility

Advanced Aluminum Technology for the Automobiles of the Future

These days, many innovations are being introduced in the automobile industry. As environmental regulations are tightened, efforts to reduce CO_2 emissions are sharpening the trend toward lighter weight and electrification, and the shift to electric vehicles is in full swing. Looking ahead to the CASE (Connected/ Automated/ Shared/ Electric) era, automobile manufacturers are now developing next-generation mobility. Based on its accumulated expertise in a wide range of fields, UACJ Corporation is vigorously developing materials and structural applications that support lightweight and electrification. The goal is to help create not only an unprecedented vision of aluminum, but also the future of the automotive industry.

Aluminum Alloy Sheets & Plates
Aluminum Alloy Extruded Shapes
Aluminum Forged Products
Aluminum Materials for Lithium-ion Batteries





UACJ Corporation

Tokyo Sankei Bldg., Otemachi 1-7-2, Chiyoda-ku, Tokyo, 100-0004 Japan

Website: www.uacj-automobile.com

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