# Eloxwell

Advanced Electrochemical Platform
for Industrial-Scale Anodization of
High-Alloyed Aluminium Parts

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## Advantages of aluminium

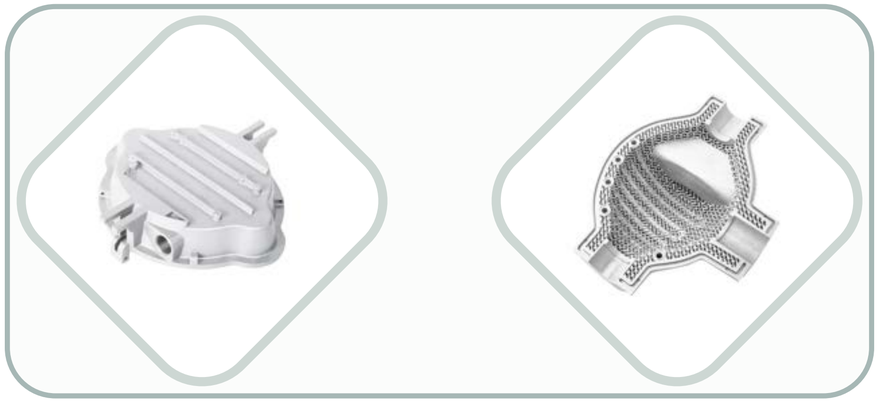
- DURABLE AND LONG LASTING
- LIGHTWEIGHT
- HIGH ELECTRICAL AND THERMAL CONDUCTIVITY
- CORROSION RESISTANT
- ENVIRONMENTALLY FRIENDLY AND SUSTAINABLE

most common production methods for aluminium parts

Scope of **Eloxwell**

**FORGE**

**EXTRUSION**

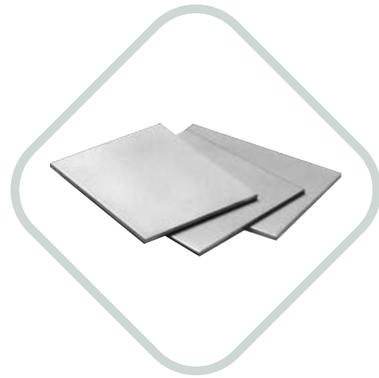


**CASTING**

(Silicon must be added)

**ADDITIVE MANUFACTURING**

(Silicon must be added)



**ROLLING**

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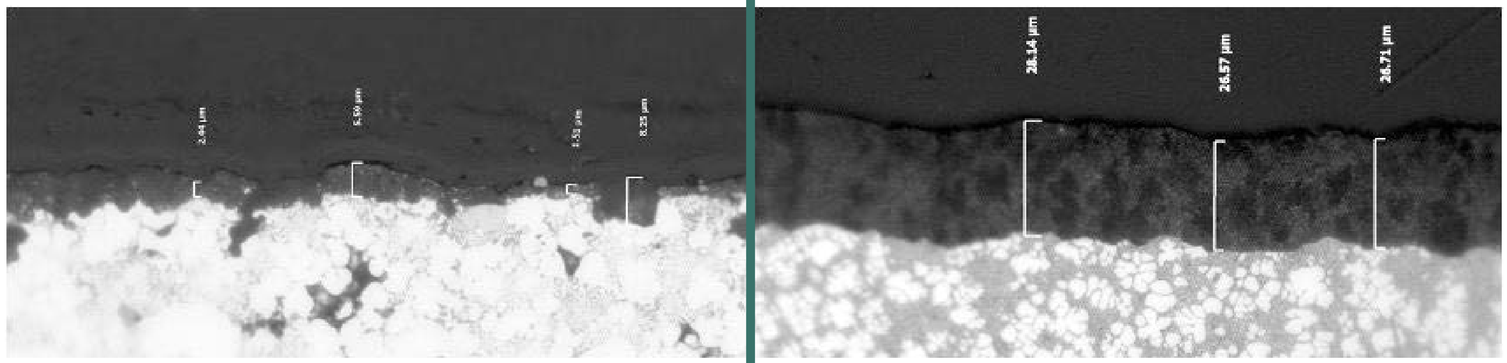
Although it is well desired both by the manufacturers and the market, large scale anodization of high alloyed aluminium components made by casting and additive manufacturing cannot be achieved with the existing anodization technology.

- HIGH SILICON CONTENT
- UNSUSTAINABLE PRODUCTION
- EXCESSIVE ENERGY CONSUMPTION
- SLOW MANUFACTURING CYCLE
- HIGH CARBON FOOTPRINT
- EXCESSIVE WATER CONSUMPTION

High-Pressure Die Cast Aluminium Parts have been anodized as a demonstration of Eloxwell Technology in a mid-size industrial level plant. (5 tons process bath)

CONVENTIONAL ANODIZATION

ANODIZATION WITH ELOXWELL TECHNOLOGY




Comparative Analysis of Anodized AlSi9Cu3Mg Alloys

**Anodization Type:** Technical anodization
**Alloy Type:** AlSi9Cu3Mg- EN AC 46000
**Production Technique:** High-Pressure Die Casting (HPDC)
**Oxide Thickness:** 30 ± 5 micrometers
**Hardness:** 350-420 Vickers (HV)
**Corrosion Resistance:** 600+ hours Neutral Salt Spray Test

Eloxwell Combines anodization process, electrochemical analysis and Artificial Intelligence.

With “Eloxwell” technology, anodized aluminum parts with complex geometries will receive an increased lifetime, reduced carbon footprint and an aesthetic appearance while adapting the aluminum industry into the green deal perspective.


1
**AUTOMATIC CHARACTERIZATION**

Electrochemical characterization of failure conditions based on aluminum alloy type

2
**COMPREHENSIVE DATABASE**

Processing material and electrochemical characterization data to determine optimum anodization parameters

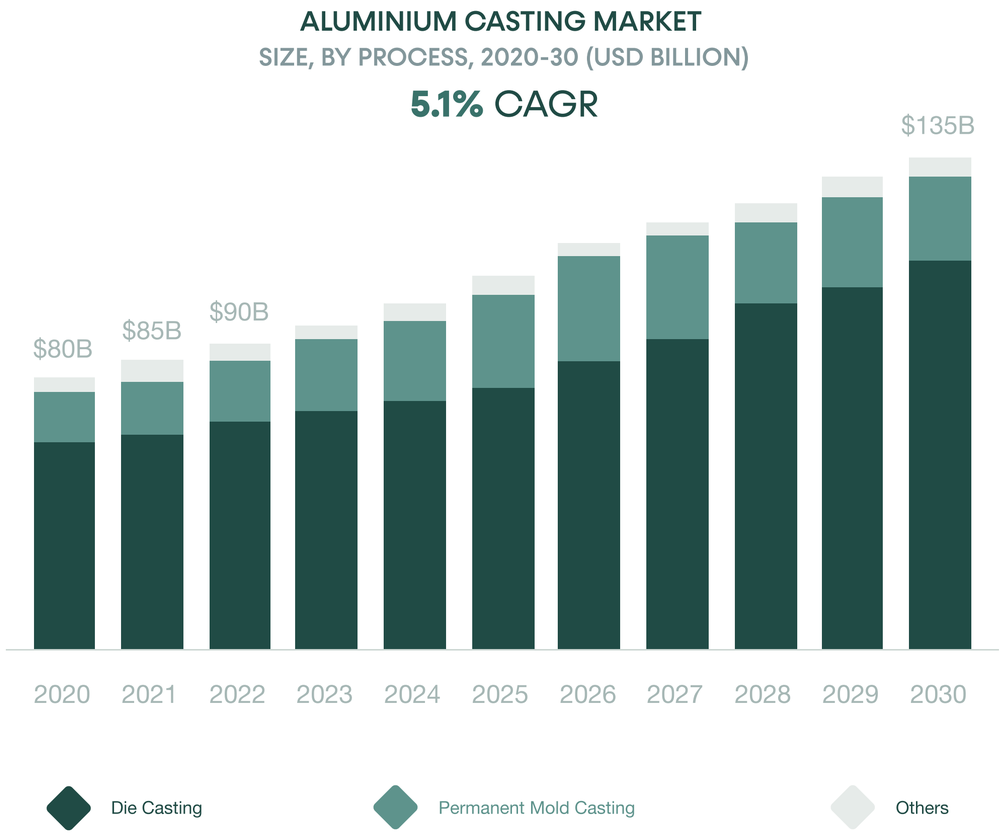
3
**CLOUD ASSISTED SOFTWARE**

Complete controlled anodization, surface characterization of anodized aluminum alloys, and failure analysis

4
**CONTROLLED PRODUCTION**

Confirmation of applicability and preparations for the transition to industrial scale production after the first customer

The aluminium casting market size will have a strong industrial orientation towards die cast aluminium.

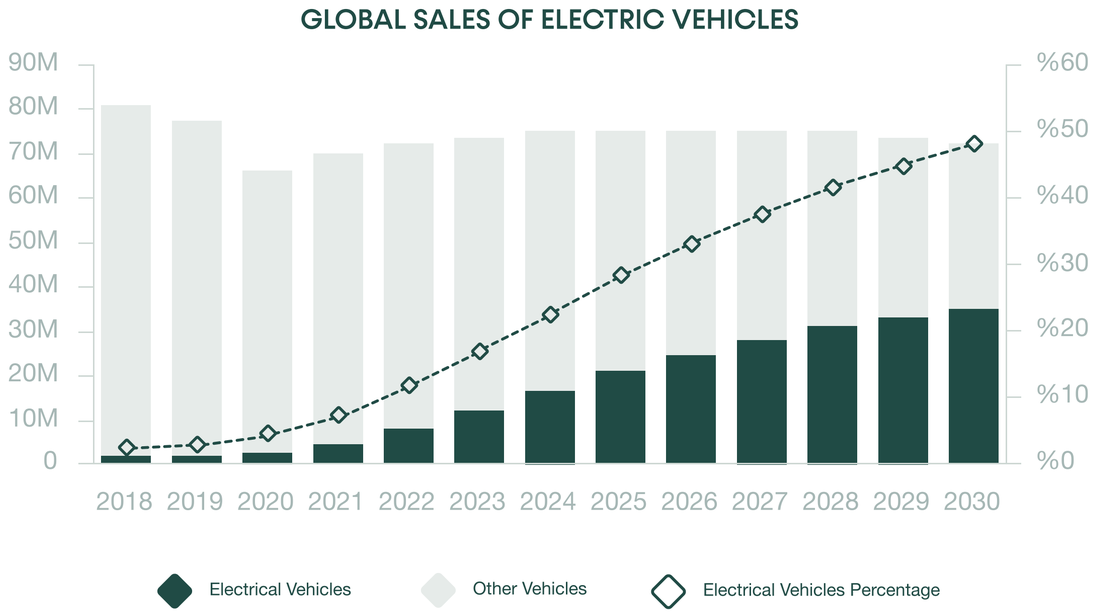



Die Cast Aluminium is expected to grow at a 5.1% CAGR from 2023 to 2030, driven by the transportation sector, which held a 58.0% revenue share in 2022. Demand for aircraft engines and construction equipment is also contributing to this growth, with the building and construction segment projected to grow at a 3.% CAGR in volume terms from 2023 to 2030.

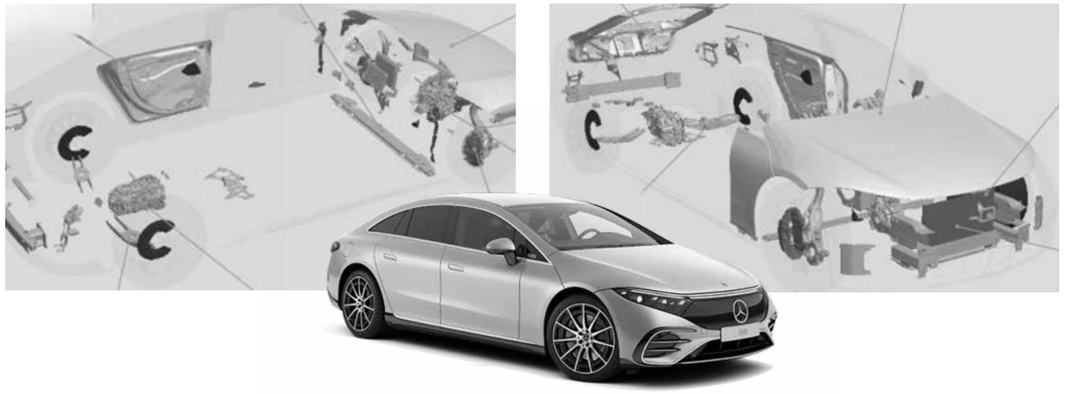
* Grand View Research, 2020-2030 Aluminium Casting Market Size Report

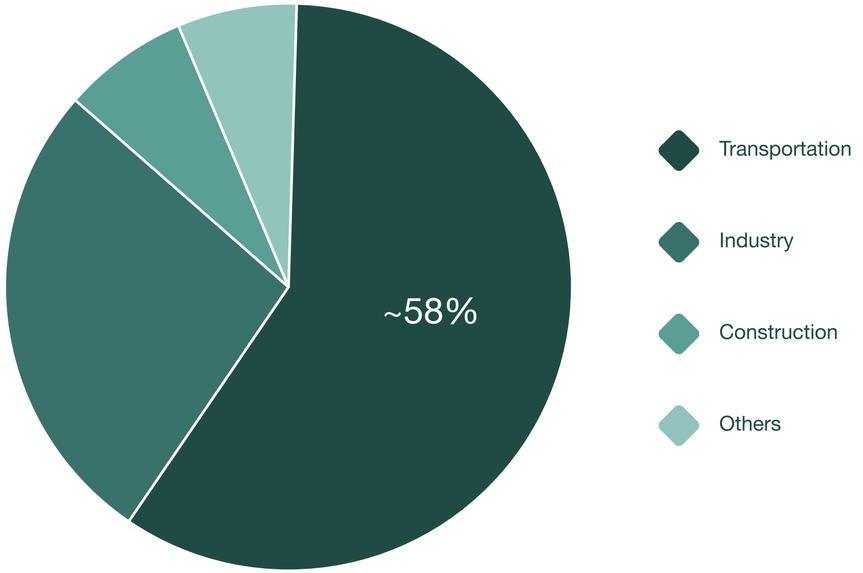
The electric vehicle market sales will detonate a strong demand for cast aluminum components.

In 2020, 6.8 million electric vehicles were in use. By 2030, half of all of the manufactured cars are predicted to be electric vehicles, which amounts into 40 million vehicles. Nearly 30-40% of aluminium is being used per lightweight vehicle every year and is likely to reach 70% over the coming years owing to stringent regulations on reducing fuel emissions across the globe.



Cast aluminum components are becoming more important due to their weight to strength ratio.






Although aluminium currently consists almost 40% of the materials used in automobiles, this percentage is anticipated to rise to 70%.

The volume of the cast aluminum industry in 2019 is $50 Billion which ~%58 of it is used in transportation. It is projected to reach $100 billion in 2026.

Since current technologies cannot satisfy the needs of the automotive industry, distruption in different verticals by Eloxwell may happen.

## Distruption in different verticals by Eloxwell

### STEEL

Among all materials, high-strength steels are most susceptible to hydrogen-induced damage.

### POWDER COATING

High Water consumption is required. can be hazardous to environmental and human health. heavy metal-containing chemicals are used.

### HEXAVALENT CHROME-FREE PASSIVATION

Limited corrosion resistance ability. surface hardness and wear resistance are not improved by passivation.

### HARD ANODIZATION

Incapable for industrial-scale. high amounts of energy and water must be consumed due to the slow process cycle.

### TYPE II ANODIZATION

Type II anodization does not give suitable results on cast aluminium alloys due to their silicon content. Its usage area is mostly restricted to extruded aluminium alloys.

## Powder Coating

Compared to the powder coating systems commonly used in the market,

Eloxwell has relatively low installation costs.

Up to 30% less water than powder paint and requires chemicals that do not contain heavy metals during the process.

The surface hardness of powder-coated parts is low, and if the surface has any paint removal, it irreversibly loses its corrosion resistance feature.

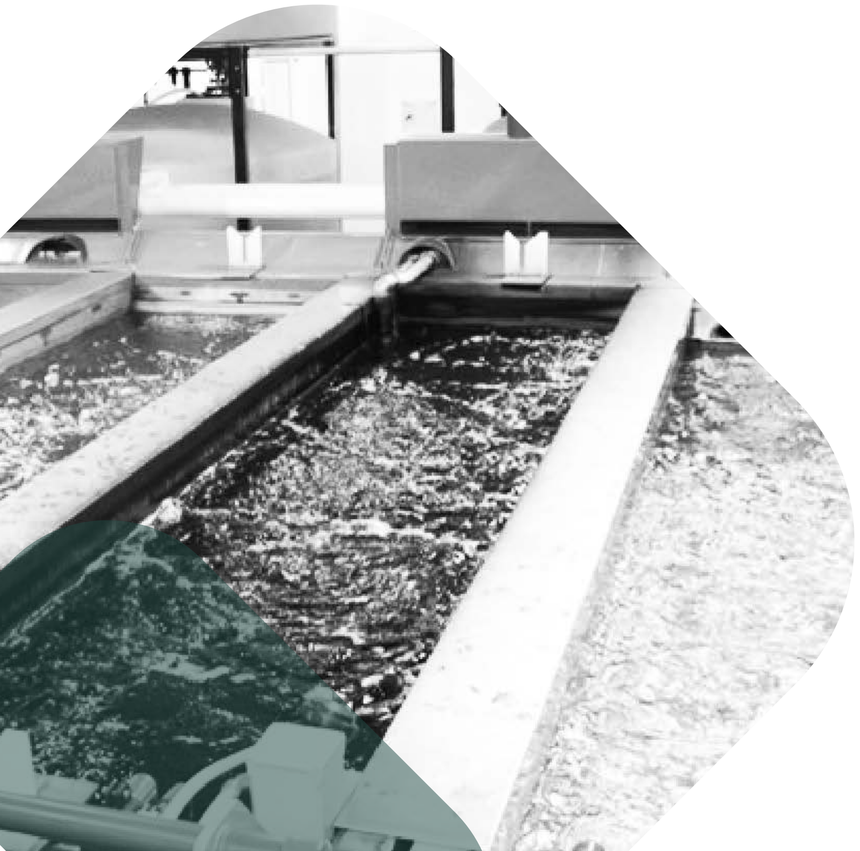
Does not contribute to the surface hardness or functional properties of cast aluminum alloys.

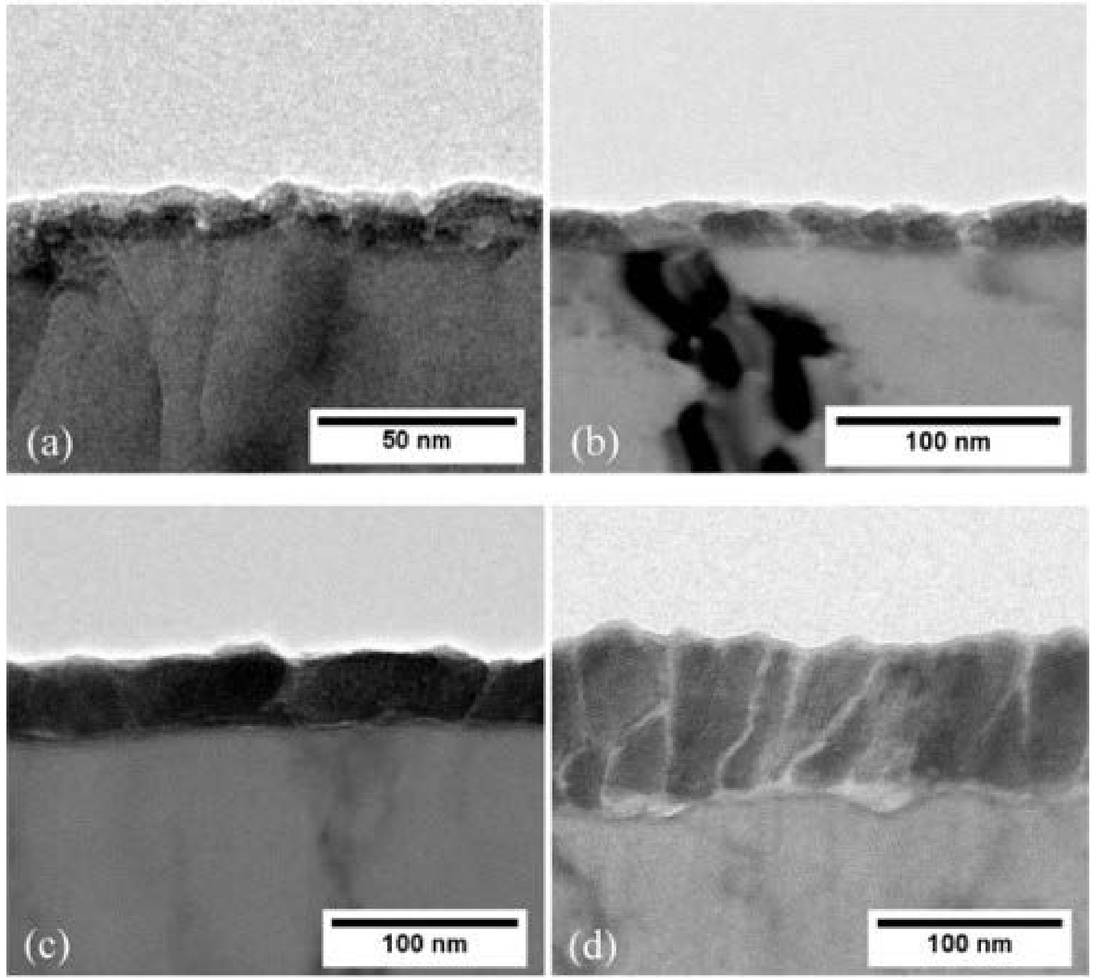
Most of the powder coating needs in our country are imported.

Eloxwell provides high UV resistance to the parts with the effect it will create.

## Hexavalent Chrome-Free Pasivasyon

The passivation process applied in Al-Si alloys ensures the formation of a protective film layer at the nanometric level on the surface. However, surface hardness, wear resistance, etc. It does not contribute to the functional properties.





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## Type II & Hard Anodization

Although hard anodizing provides only a slight increase in corrosion resistance and hardness, there are major obstacles in applying this method to casting alloys on an industrial scale;

High amount of electricity and water consumption

Low anodization bath conditions

Slow process cycle

Inhomogeneous oxide thickness

Limited Oxide thickness

Low hardness and wear resistance

Inhomogeneous color and appearance

# Eloxwell | Competition

Eloxwell is the most competitive surface treatment anodization technology.

| | A revolutionary, innovative approach: “Eloxwell” | Alternate surface treatment anodization technologies do not exhibit the benefits by iyiMetal | | Most companies (>99%) are only certified for architectural applications |
|---|---|---|---|---|
| **Technical Features** | iYiMETAL | **Aalberts Surface Treatment** | **Cidetec Surface Treatment** | **Other Anodization Companies*** |
| Scrap Rate | ✓ | ✗ | ✗ | ✗ |
| Software Controlled Process | ✓ | ✗ | ✗ | ✗ |
| Homogenious Coating | ✓ | ✓ | ✗ | ✗ |
| Energy Consumption | ✓ | ✗ | ✗ | ✗ |
| Production Duration | ✓ | ✗ | ✗ | ✗ |
| Surface Hardness | ✓ | ✓ | ✗ | ✗ |
| Wear Resistance | ✓ | Unknown | Unknown | ✗ |
| Corrosion Resistance | ✓ | ✗ | ✗ | ✗ |
| Aesthetic Appearance | ✓ | ✗ | ✗ | ✗ |
| Water Consumption | ✓ | ✗ | ✗ | ✗ |
| Surface Roughness | ✓ | ✓ | ✗ | ✗ |

# Eloxwell | Specific Characteristics of Anodized Cast Aluminium Alloys

Eloxwell technology provides the desired properties for cast aluminium alloys compared to other anodization techniques.

| Technical Features | Eloxwell | Hard Anodization | Type II | Passivation |
|---|---|---|---|---|
| Energy Consumption (kWh/dm2) (for 10µm) | 0,04* | 0,5 | 0,3 | 0,2 |
| Standard Deviation (for 10 µm) | ±2 | ±7 | ±5 | N/A |
| Applicable Alloy Type | 1% - 12% of all Si-containing Alloys | Limited Al-Si Alloys | Limited Al-Si Alloys | 1% - 12% of all Si-containing Alloys |
| Maximum Coating Thickness (µm) | 100 | 30 | 5 | 0,1 |
| NSS Corrosion Resistance Period | 720-1000 hours* | 360 hours | 240 hours | 360 hours |
| Coating Hardness (HV) | 400 HV* | 350 HV | Not Measurable | Not Compatible |
| Process Speed (for 10 µm coating) | 5 min | 60 min | 90 min | 5 min |
| Roughness at 20 micrometer | 2,5* | 9 | Not Applicable | N/A |
| Operational Challenge | Easy | Hard | Medium | Easy |

* The technical characteristics and production conditions vary depending on the desired surface properties, alloy type, and casting method.

# Eloxwell | Advantages of Anodized Cast Aluminium Alloys

Using Eloxwell and cast aluminium provides numerous advantages in terms of sustainability and surface quality.

### Layer Thickness and Tolerances

The distribution of oxide thickness is strongly dependent on the base metal type.
**Oxide Thickness Tolerances Based on Silicon Content*

### Process Time

The process duration directly depends on the desired coating thickness, alloying elements, and technical requirements.
**For example, 30 µm anodized layer can be obtained in 30 minutes with Eloxwell technology, but it can be reduced to as short as 2 minutes when high technical properties are not requested.*

### Corrosion Protection

Anodizing produces a thick layer of oxide, which improves corrosion resistance. The passive film is chemically inert and will not degrade or corrode in atmospheric conditions.

### Wear Resistance

The hardness and morphology of aluminium oxide nanotubes directly affect the high wear resistance. Eloxwell Technology can easily optimize the required parameters to obtain hard and smooth surfaces to improve the tribological properties of aluminium components.
**Taber abrasion test cannot be applied on the complex-shaped parts.*

### Low Carbon Footprint

Because of its low energy, water, and chemical requirements, anodization is a more environmentally friendly coating method than other protective coatings.

### Recyclability

Anodization causes the formation of a natural oxide on aluminium surfaces. As a result, unlike powder coating, a small amount of oxide has no negative impact on the recycling and quality of recycled aluminium.

### High Surface Hardness

After diamond, aluminium oxide is the second hardest material. Anodization forms a distinct oxide layer on aluminium alloys, providing a hard and durable surface finish.

### Mechanical Strength

Aluminum and aluminum alloys are available in a wide range of strength values-from highly ductile low-strength commercially pure aluminum to very tough high-strength alloys with ultimate tensile strengths approaching 690 MPa (100 ksi)

### Roughness

Eloxwell is distinguished from conventional anodizing by its specific parameter determination to achieve a relatively low rate of roughness, which varies between Ra = 0.1-0.5 µm depending on the substrate used.
**Roughness increases less if the base metal's surface roughness is low.*

### Weight Reduction

Aluminium has a much higher strength-to-weight ratio than many common steel grades, often by a factor of two or more. This property enables the design and construction of strong, lightweight structures, which have been extremely effective in the automotive industry.

### Aesthetic Appearance

Anodization forms a transparent oxide layer on the surface of the aluminium. As a result, the metallic appearance and texture remained with the various color options after anodization.

### Electrical Conductivity

Aluminium is a good electrical conductor and is often used in electrical transmission lines. It is cheaper than copper and its electrical conductivity is twice of copper for equal weights.

### Adhesive

The porous surface of anodized aluminium has a higher contact area and more adherent spots. Because of the pores, the glue or powder paint can partially embed into the surface, resulting in an even layer with excellent adhesion.

Cast aluminium content is distributed between 12 component families, each of which encompasses a various number of components - for Electrical Vehicles

## 1 Functional Coatings

Cast aluminum parts that operate in harsh environments require a hard, thick, and durable anodic oxide layer.

- **Steering Units**
  Column Housings, Rack & Pinion Housings, etc.
- **Brake Components**
  Rotor Hats, Electric Brake Booster, etc.
- **Housings**
  Starter Motor, Water Pump, Sunroof Motor Housing, EV Gearbox Housing, etc.
- **Powertrain Units**
  Transfer Plates, Brackets, Automatic & CVT Cases, Clutch Housing, etc.

## 2 Corrosion Resistant Coatings

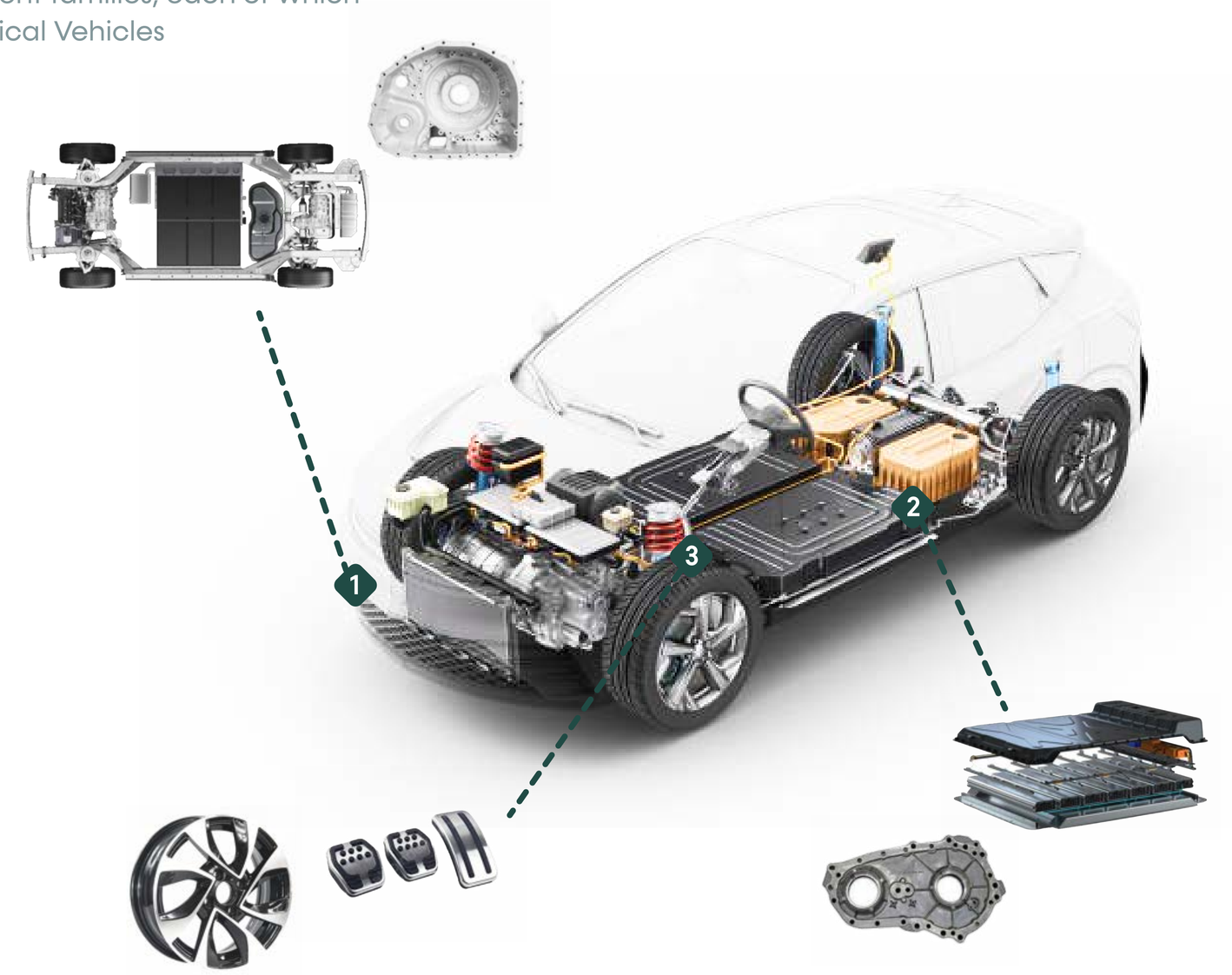
Aluminium alloys used in stationary parts only require a corrosion-resistant coating, which can be obtained quickly through the Eloxwell anodization process.

- **Structural Compenents**
  Chassis, Steering, Suspension, etc.
- **Covers**
- **Battery Cases & Covers**

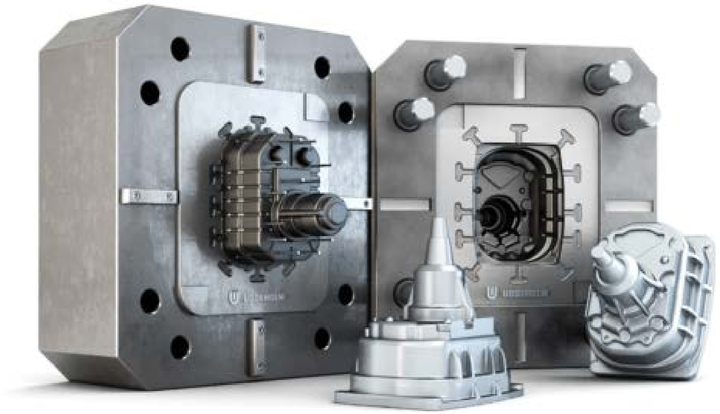
## 3 Anodization for Aesthetic Parts

Cast aluminum parts can be anodized to provide a bright metallic appearance in various colors, enhancing their aesthetic appeal.

- **Brake Calipers**
- **Interior Parts**
- **Wheels**



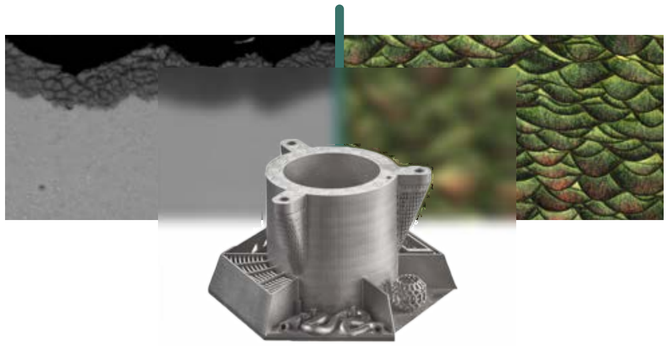
# Eloxwell | Types of Aluminium Alloys and Its Anodization Characteristics



| Aluminium Alloys containing 1-6% Silicon | Aluminium Alloys Containing 7-8% Silicon | | Aluminium Alloys Containing 9-12% Silicon | |
|---|---|---|---|---|
| EN AC-41000 (AlSi2MgTi)<br>EN AC-45100 (AlSi5Cu3Mg)<br>EN AC-45300 (AlSi5Cu1Mg)<br>EN AC-45400 (AlSi5Cu3)<br>EN AC-45000 (AlSi6Cu4)<br>EN AC-45000 (AlSi6Cu4)<br>EN AC-51500 ( AlMg5Si2Mn) | EN AC-46000 (AlSi9Cu3)<br>EN AC-46300 (AlSi7Cu3Mg)<br>EN AC-46400 (AlSi9Cu1Mg)<br>EN AC-46500 (AlSi9Cu3(Fe)(Zn))<br>EN AC-46600 (AlSi7Cu2)<br>EN AC-71100 (AlZn10Si8Mg)<br>EN AC-71100 (AlZn10Si8Mg) | EN AC-42000 (AlSi7Mg)<br>EN AC-42100 (AlSi7Mg0.3)<br>EN AC-42200 (AlSi7Mg0.6)<br>EN AC-43300 (AlSi9Mg)<br>EN AC-44400 (AlSi9)<br>EN AC-45500 (AlSi7Cu0.5Mg)<br>EN AC-46000 (AlSi9Cu3(Fe)) | EN AC-44200 (AlSi12)<br>EN AC-44300 (AlSi12(Fe)(a))<br>EN AC-44300 (AlSi12)<br>EN AC-44500 (AlSi12(Fe)(b))<br>EN AC-46100 (AlSi11Cu2(Fe))<br>EN AC-46200 (AlSi9Cu3)<br>EN AC-47000 (AlSi12(Cu))<br>EN AC-47100 (AlSi12Cu1(Fe))<br>EN AC-48000 (AlSi12CuNiMg) | EN AC-43000 (AlSi10Mg)<br>EN AC-43200 (AlSi10Mg(Cu))<br>EN AC-43400 (AlSi10Mg(Fe))<br>EN AC-43400 (AlSi10Mg)<br>EN AC-43500 (AlSi10MnMg)<br>EN AC-44000 (AlSi11)<br>EN AC-44100 (AlSi12(b))<br>EN AC-44200 (AlSi12(a))<br>EN AC-48100 (AlSi17Cu4Mg) |
| **Technical Characteristics** | **Technical Characteristics** | | **Technical Characteristics** | |
| **Thickness**<br>10 µm up to 50 µm, thickness tolerance +-5 µm<br>**Corrosion Resistance**<br>(Neutral Salt Spray Test): 1200 h<br>**Hardness**<br>350 +- 50 HV<br>**Color and Appearance**<br>Bright metallic appearance with various colors up to 25 µm, greyish base color after 25 µm | **Thickness**<br>10 µm up to 50 µm, thickness tolerance +-5 µm<br>**Corrosion Resistance**<br>(Neutral Salt Spray Test): 900 h<br>**Hardness**<br>350 +- 50 HV<br>**Color and Appearance**<br>Bright metallic appearance with various colors up to 25 µm, greyish base color after 25 µm | | **Thickness**<br>10 µm up to 50µm, thickness tolerance +-5 µm<br>**Corrosion Resistance**<br>(Neutral Salt Spray Test): 720 h<br>**Hardness**<br>350 +- 50 HV<br>**Color and Appearance**<br>Greyish base color after 5 µm<br>**Dark black color can be obtained* | |

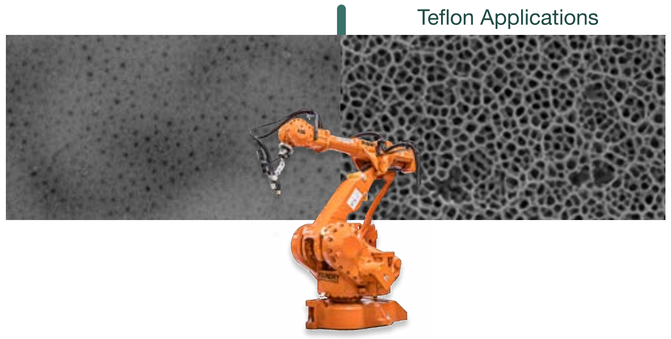
# Eloxwell | Other Applications

Thanks to Eloxwell Technology's capabilities, unique applications of aluminium can be created to meet special needs. Anodized cast aluminium has potential applications in industries such as aviation, robotics, defence, and space.



### UNIQ[illegible] MANUFACTURED ALUMINIUM ALLOYS (ALSI10MG)

Additively manıfactured parts can be anodized to protect parts from corrosion as well as decrease surface roughness for aerospace applications.

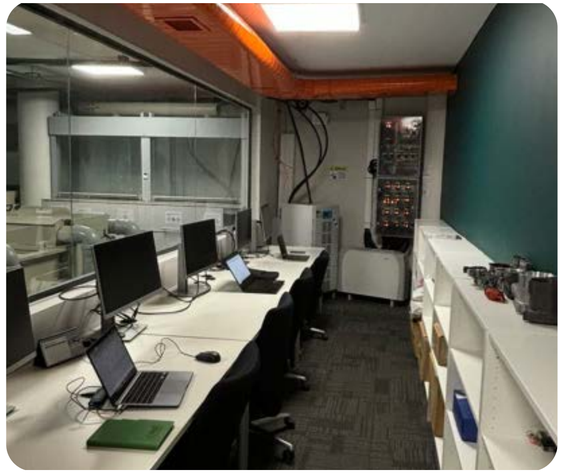



### NON-STICK SELF-LUBRICANT SURFACE COATINGS

For extremely hard and wear-resistant applications, Eloxwell Technology offers various solutions. The unique coating structure allows for a non-stick surface suitable for industrial applications.

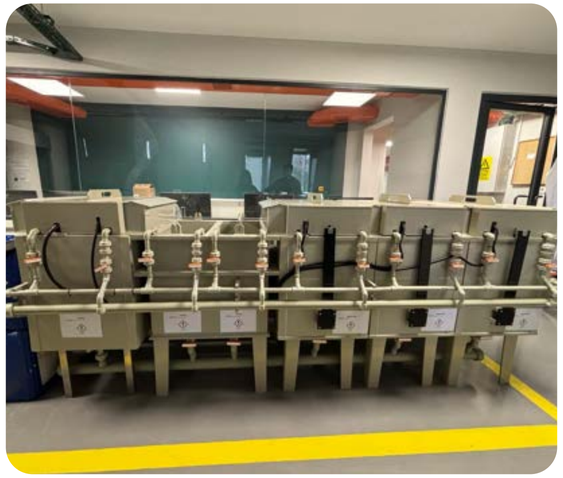
### REPLACEMENT OF CONVERSION COATING PROCESS FOR POWDER PAINT APPLICATIONS

Heavy metal-containing chemicals are used to improve the adhesivity of the powder paint layer to aluminum. With the Eloxwell technology, the adhesive thin anodic oxide can be obtained. Thanks to this, conversion coating chemicals and rinsing procedures can be eliminated so more efficient and eco-friendly production can be achieved.

Control Unit

Anodization Line



Coloring and Surface Finishing Line

Pretreatmant and Chemical Etching Line

# Eloxwell | Co-Founders

Under the Scientific Advisory of Prof. Dr. Mustafa Ürgen, we continue our activities with a team of 9 people in total composing of 4 metallurgical engineers and 5 other disciplines.

**SİNAN ZABUNOĞLU**

Chief Executive Officer

ODTÜ METU

**GÜNEY AKDAŞ**

Chief Technological Officer

+

**PROF. DR. MUSTAFA ÜRGEN**

Chief Scientist Advisor

CO-FOUNDERS

ADVISORS

# Eloxwell

iyiMetal aims to provide sustainable anodization technology that can be used as a globally accepted standard technology across several industries.

iYiMETAL