ALUMINIUM:
SURFACE WITH MANY FACETS

Aluminium alloys have special properties (such as high specific strength and rigidity) and are capable of passive layer formation, which, in conjunction with an attractive surface finish, makes them an attractive package for lightweight and design applications.

Importance of surface technology

As a premium manufacturer of aluminium semis for various markets and applications, AMAG is well aware of the importance of attractive surfaces. AMAG uses its broad application expertise, ranging from aircraft, automotive, sports and leisure applications to bright surfaces for the lighting industry, to develop new applications jointly with the customer.

AMAG's Surface Technology department plays a special role in this process; it performs corrosion release tests and is the contact for all questions concerning surface treatment of aluminium.

Extensive know-how in the production of semi-finished products (metallurgy, heat treatment) and a clear idea of the customer's subsequent processes are vital in developing and improving the surface and corrosion properties of aluminium semis. Changes in the microstructure of materials (e.g., type and chemical reactivity of precipitates, precipitate size and density, grain structure) and in surface properties (roughness, wettability, residual oil content) may lead to large differences in subsequent surface treatment.

Development know-how in surface technology

The Surface Technology department with its well-equipped testing laboratory and a surface testing laboratory supports the development of new applications of various aluminium materials. A large number of corrosion tests can be performed, tailored to the anticipated service load. A new corrosion testing chamber allows humidity and temperature cycles, combined with salt spray phases, to be mapped and reliably covers, e.g., most cyclic corrosion tests in the automotive area.

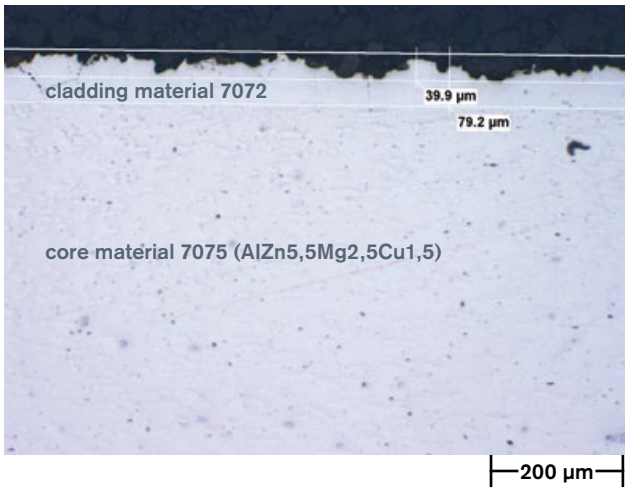

Fig. 1: Surface attack on the cladding in the exfoliation corrosion test according to ASTM G34

In order to further enhance corrosion resistance, the compositions of alloys and the production processes for aluminium strips are optimized in close cooperation with mill technologists. Corrosion protection is achieved, e.g., by the use of so-called clad alloys, which are produced during hot rolling by forming a metal bond between a high-alloy base metal and an outer layer of pure aluminium. This protection layer has a less noble electrochemical potential and dissolves on corrosion attack, whereas the base metal is not attacked, which is shown, e.g., in the exfoliation corrosion test (Fig. 1). By changing the composition and adjustment of the production steps, claddings are designed that offer the same degree of corrosion protection yet provide a more stable surface for coating. Ideally, the cladding should also be heat-treatable to increase the overall strength of the bond.

On a test anodizing mill built in 2010, sample sheets of sizes up to A3 can be electrochemically brightened, anodized and coloured, which is ideal for the development of high-quality aluminium surfaces as used in electronic components such as cell phone shells or notebook cases. Apart from providing attractive surface finish options (e.g., colour anodizing), the use of high-strength aluminium materials also ensures a remarkable increase in mechanical and thermal stability, which plays an increasing role in an ever more compact design.

New sol-gel coatings are being developed jointly with research partners. These layers are formed by a cross-linking reaction after application to the aluminium strip. Depending on the composition of the starting components, paint- to glass-like coatings are →

produced by baking at temperatures ranging between 150 °C and 300 °C. The surface properties that can be achieved range from easy-to-clean, corrosion and scratch protection to special visual effects such as brightness enhancement. These systems have the great advantage of reacting with the aluminium surface, regardless of its chemical composition, and of forming very stable layers.

Adhesively bonding aluminium materials is becoming increasingly important because the wide range of materials to be bonded is ever increasing. Adhesively bonded joints with high stability and long-term durability are in demand. Bonding pretreatment should be highly versatile and environmentally friendly. AMAG has designed a pre-treatment line for heat-treatable strips for the application of up to four different materials using state-of-the-art roll coating as well as conventional spray systems. Again, sol-gel-based silane coatings promise significantly higher performance compared to conventional conversion layers. Like paints, they can be applied in a coil-coating process. The Surface Technology department supports the adoption of such processes through extensive laboratory pretesting. A state-of-the-art X-ray fluorescence analyzer (XRFA) and a contact resistance measurement unit are available to characterize the layers. The quality of various pre-treatment conditions can be assessed by performing aging tests on adhesively bonded specimens. ■

The table below provides an overview of surface coatings, application methods, achievable properties and fields of application:

Coating	Process	Properties	Products	Market
Ceramic, oxide	Anodizing, sol-gel, spark anodizing, plasma coating	Hard, abrasion-proof, corrosion protection, decorative (brightness, coloring)	High-strength alloys (2xxx, 6xxx, 7xxx)	Mechanical engineering, sports articles, electronics
Silane, siloxane	Dipping, roll coating, sol-gel, CVD, plasma coating	Surface protection, adhesion promotion, anti-soiling	Treadplates, commerce (5xxx, 6xxx)	Façade construction, mechanical engineering
Optical layers	Sputtering, PVD, sol-gel	Enhanced reflection, maximized absorption	Bright surfaces (1xxx, 3xxx, 5xxx)	Lighting, cosmetics, decorative elements, solar applications
Adhesion promoter	(Flash) anodizing roll coating, plasma coating	Chemical stability, mechanical stability, preparation for adhesive bonding, painting	Titanal®, automotive (2xxx, 6xxx, 7xxx)	Ski industry, automotive industry, composite materials
Passivation	Roll coating, dipping, spraying	Long-term durability of adhesively bonded joints	Automotive sheets (6xxx)	Automotive industry
Foils, paints, sol-gel layers	Lamination, roll coating, spraying	Decoration, functionalization	All	Design, leisure, household

Measurement of the passivation layer by X-ray fluorescence analysis