Products

Unique Anodized Film for Bonding Aluminum and Resin*

Akihiro Fukatsu**, Yoshiyuki Oya*** and Yoichi Kojima****

1. Introduction

The importance of joining technology for different materials is continually increasing. Mechanical fastening or adhesion bonding is often performed when joining aluminum sheets with resin. Adhesion can join any shape, including large-area bonding, thin-plate bonding, laminates, and honeycomb structures. Moreover, adhesion reduces the stress concentration and improves fatigue characteristics because it involves surface bonding. In contrast, disadvantages of adhesion include insufficient bonding strength and its deterioration after long periods of use. Therefore, aluminum sheets are often subjected to surface treatments to increase the adhesive strength and/or improve durability. Conventionally, various chemical conversion treatments have been used for bonding substrates such as phosphoric acid and chromate, as well as anodizing as a bonding-base-treatment. Recently, significantly demand for the development of such surface treatment technology to deal with a diverse combination of materials to further improve the reliability of composite materials has been generate. In addition, a major goal is to reduce the environmental impact of the treatment process. To meet these technical and social demands, a novel surface treatment for bonding substrates was developed involving alternating current (AC) anodizing in an alkaline solution without heavy metals such as Cr. "KO Processing Sheet"[1] has been developed to meet these demands which has an oxide film with a unique shape and high resin adhesion. In this paper, we describe the oxide film structure and adhesive properties.

2. Method

Herein, 5052-H34 aluminum sheets were used as specimens. AC electrolytic treatment was performed in an alkaline solution and subsequent washing with water and drying yielded an aluminum sheet with an AC anodized film. **Fig. 1** shows a schematic of the treatment process.

3. Results

3.1 Film structure

A top-view FE-SEM image of the AC anodized film and cross-sectional TEM image were provided in **Fig. 2** (a) and (b) respectively. The oxide film exhibited a complex porous-and-dendritic structure with a pore diameter of 10 to 30 nm and thickness 100 to 300 nm.

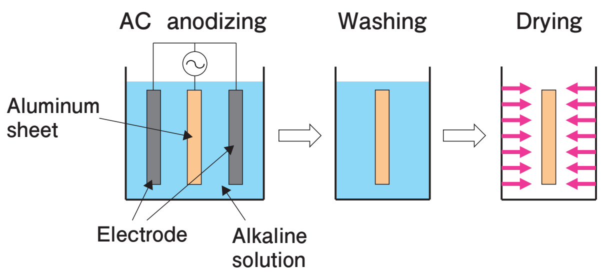

Fig. 1 The AC anodizing process.

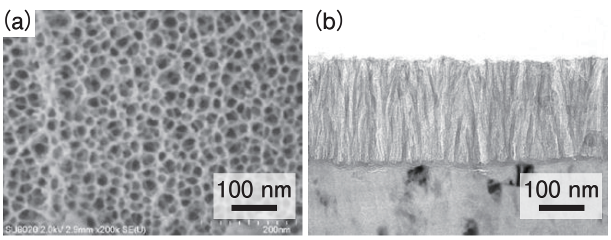

Fig. 2 (a) A top-view FE-SEM image and (b) cross-sectional TEM image of the AC anodized film.

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** Research Department II, Research & Development Division, UACJ Corporation
*** Research Planning Department, Research & Development Division, UACJ Corporation, Ph. D. (Eng.)
**** Research & Development Division, UACJ Corporation, Ph. D.

The pores were much thinner than those produced in conventional anodized films formed by direct current (DC) electrolysis in sulfuric acid solution (thickness of 2000 to 10000 nm). In addition, the prepared oxide film contained a smaller amount of impurities than the DC film.

3.2 Primary adhesion: the tape peeling test

The 90° peeling strength of the samples was measured using polyester tape. For comparison, the peeling strengths of DC anodized, phosphate chromatized and bare aluminum were also measured. High tape peel strength was obtained for both AC and DC anodized materials (**Fig. 3**). A glue mark was observed only on the AC anodized surface (**Fig. 4**).

3.3 Durability of the primary adhesion: exposure to atmospheric conditions

Fig. 5 shows the time-dependent changes of tape peel strength when the AC anodized aluminum sheet was exposed to air for 6 months. Ordinarily, adhesion strength decreases remarkably due to moisture absorption and surface contamination if it is exposed to air without adhesion or painting. However, this surface treated specimen exhibited almost no decrease in strength.

3.4 Secondary adhesion: the pressure cooker test

The aluminum sheet and polypropylene resin were directly bonded via thermocompression. The sample was then exposed to 121°C and 100% RH conditions for 32 h. The time-dependent change of the T-peel strength was shown in **Fig. 6**. The strength of the DC anodized specimen prepared in sulfuric acid solution decreased significantly. In contrast, the AC anodized specimen in the alkaline solution showed negligible decreases in strength.

4. Discussion

The interface of the aluminum and resin was observed by TEM-EDS. At the aluminum/resin interface, Al and O atoms derived from the oxide film and C atom derived from the resin were detected (**Fig. 7**). The high adhesive strength was likely obtained by the resin penetrating into the complex porous-and-dendritic oxide film and exhibiting a strong anchor effect.

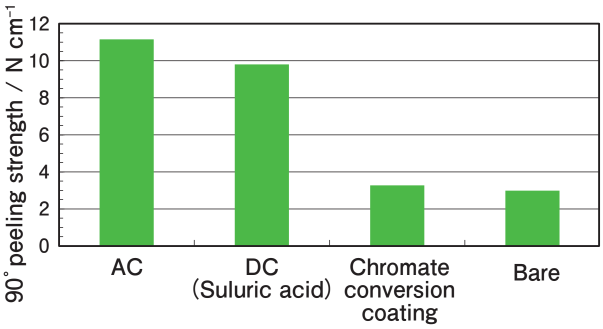

Fig. 3 The 90° peeling strength of various surface treatments for acrylic adhesives.

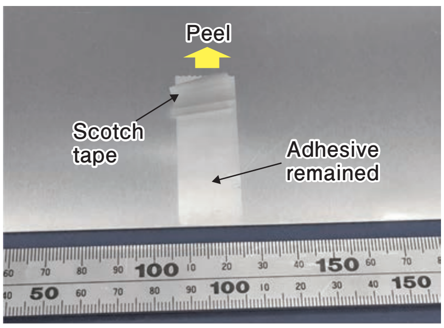

Fig. 4 Picture of the AC anodized film before/after the peeling test.

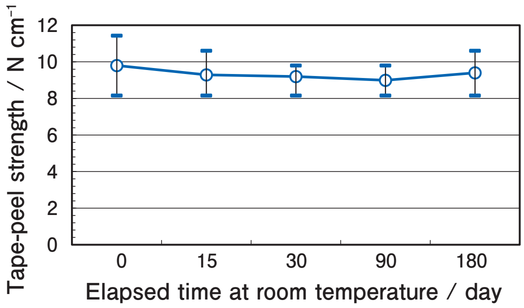

Fig. 5 Change in the 90° peeling strength of the AC anodized film as a function of exposure time to the atmosphere.

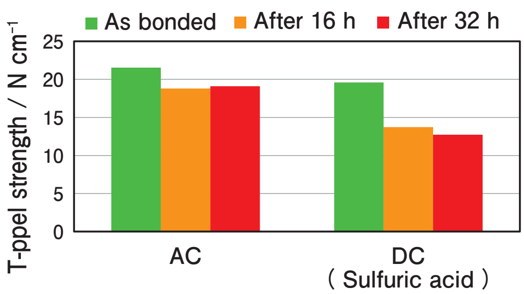

Fig. 6 T-peel strength of the AC and DC anodized films for epoxy bonding.

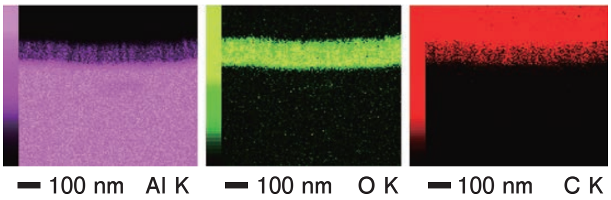

Fig. 7 Composition mapping of the aluminum/resin interface.

5. Conclusions

An anodized film was prepared with complex porous-and-dendritic structures on an aluminum surface by AC electrolysis in an alkaline solution and adhered to resin. High bonding strength was obtained because the resin entered the micropores of the oxide film, developing an anchor effect. The bond strength of the AC anodized film was stable over 6 months of exposure to atmospheric conditions before bonding and when exposed to high-temperature and high-humidity conditions after bonding. The surface treatment technology developed herein is promising for the direct bonding of aluminum and resin without using adhesives.

REFERENCE

1) Shinichi Hasegawa et al.: "Resin bonding mechanism onto the AC electrolysis aluminum material", Journal of Light Metal Welding, **51** (2013), 473–475.

Contact

UACJ corporation, Flat Rolled Products Division,
Industrial Materials Marketing & Sales Department
Tokyo Sankei Bldg., Otemachi 1-7-2 , Chiyoda-ku,
Tokyo 100-0004, Japan
Tel: +81-3-6202-2672 Fax: +81-3-6202-2031

Akihiro Fukatsu
Research Department II,
Research & Development Division,
UACJ Corporation

Yoshiyuki Oya
Research Planning Department,
Research & Development Division,
UACJ Corporation, Ph. D. (Eng.)

Yoichi Kojima
Research & Development Division,
UACJ Corporation, Ph. D.