DEVELOPMENT OF ALUMINUM ANODIZED COATING WITH EXCELLENT THERMAL PROPERTIES

MATSUFUMI TAKAYA*, MASATSUGU MAEJIMA**and KOHICHI SARUWATARI***

* Department of Precision Engineering, Chiba Institute of Technology
(17-1, Tudanuma 2-chome, Narashino-shi, CHIBA 275-0016, JAPAN)

, * MATERIAL TECHNOLOGY LABORATORY, Fujikura Ltd.
(1-5-1, Kiba, Koto-ku, Tokyo 135-8512, JAPAN)

ABSTRACT

We have developed on aluminum anodized coating with excellent thermal properties. This coating is made by anodizing in 0.3 M $KMnO_4$ aqueous solution and is constituted of a very pourous layer about 10 μm thickness and looks black. In thermal properties, it has a higher and more stable spectral emissivity as far-infrared radiation material compared to ordinary black-dyed anodized coating. We consider that this porous black layer contains MnO_2 well-known for its high emissivity potential. This coating offers excellent possibilities for applications in many fields of industry.

Keywords: *Aluminum, anodizing, $KMnO_4$, irregular layer, emissivity, breakdown*

INTRODUCTION

In this paper we describe the experimental process for producing a manganese oxide layer with high emissivity as far-infrared radiation and a rough aluminum surface containing irregular pores with excellent heat conductivity.

EXPERIMENTAL

Material - A 1100 (1 × 25 × 100mm) was used in experiments.

Anodizing - The concetration of potassium permanganate was 0.3 M. The bath temperature was 30±3 ℃. Anodic current density was 2.5 A/dm² and anodizing time was 30 minutes. The cathode was a platinum plate. The maximum thickness of anodized layer was about 10μm.

Measurements - ① Change of anodic current in $KMnO_4$ aqueous solution with potentiostat.

② The appearance of surfaces of the layers during the forming process.

③ The appearance of cross sections of the layer after anodizing for 30 minutes scanned by electron microscopy.

④ Analysis of the composition of the layer by X-ray diffractometry.

⑤ Analysis of the composition of the layer by plasma emission spectroscopy.

⑥ Analysis of the emissivity as far-infrared radiation at 200℃.

RESULTS and DISCUSSION

Fig.1 shows the results of the changes in anodic current in the potentiostat. Anodic current decreases gradually as anodic oxidation proceeds.

Fig.2 shows the external section of the layer during the forming process. Obviously the layer has formed through the breakdown phenomenon.

Fig.3 shows the cross sections of the layer. Similarly as Fig.2 many porous pits are observed all over the land.

Fig.4 shows the relation between electrolytic voltage and time for 30 minutes. For reference the same relationship is examined in 22wt% sulfuric acid. Electrolytic voltage increases about 4-fold its initial value. In $KMnO_4$ aqueous solution the layer is formed by repeated cycles of the breakdown phenomenon and has a rough and irregular porous surface. Accordingly the maximum thickness of the layer is about 10 μm because when breakdown occurs at every section on the surface of the aluminum, formation of the layer stops.

Fig.5 shows the results of X-ray diffractometry on the black-colored layer with 10μm thickness formed in $KMnO_4$ aqueous solution. There are MnO, MnO_2, Mn_2O_3, $Mn(OH)_2$ molecules and Al particles in the layer. We presume that amorphous Al_2O_3 is probably present in the layer but could not find from X-ray diagram since it dose not elucidate.

Fig.6 shows the plasma emission spectroscopy on the black-colored layer. There are manganese oxides on the outside but Aluminum particles are hardly seen. In these results we can conclude the difference of constructions of the layer between anodizing in $KMnO_4$ aqueous solution and sulfuric acid.

Fig.7 shows the results of measurements of emissivityr as far-infrared radiation from black-colored layer formed in $KMnO_4$ aqueous solution and the normal layer with 15μm thickness formed in sulfuric acid then dyed with organic black dyes, within the range of wave length from 4μm to 16 μm at 200℃. For the normal layer the emissivity is unstable within 7~8μm in wave length but in the developed layer the emissivity is very stable and 60% or more of the incident radiation.

CONCLUSIONS

We succeeded in producing the black-colored layer with excellent thermal properties such as emissivity as far-infrared radiation by using anodic electrolytic oxidation in $KMnO_4$ aqueous solution. This layer which is formed through the breakdown phenomenon is irregular, pourous and black-colored surface containing some manganese oxides.

This layer has a very stable spectral emissivity due to its extremely wide surface area, some manganese oxides and black-colored surface. This layer will contribute to efforts aimed at the efficient and conservative use of energy.

REFERENCE

[I] M.Takaya, M.Maejima and K.Saruwatari:Proc.the 93rd Conference of Jpn.Inst.Light Metals, (1997),247.

[II] M.Maejima, M.Matsuo, K.Saruwatari and K.Isawa:Hyomen Gijutsu, 41, 128 (1998).

[III] M.Maejima, K.Saruwatari, M.Hirata, H.Osanai, K.Isawa, S.Nishiyama and S.Matsumoto: Fujikura Giho, No.82.pp63-69, (1992).

[IV] M.Maejima, K.Saruwatari, M.Hirata, M.Saito and Y.Seino:Fujikura Giho, No.86.pp98-104, (1994). (1997).247.

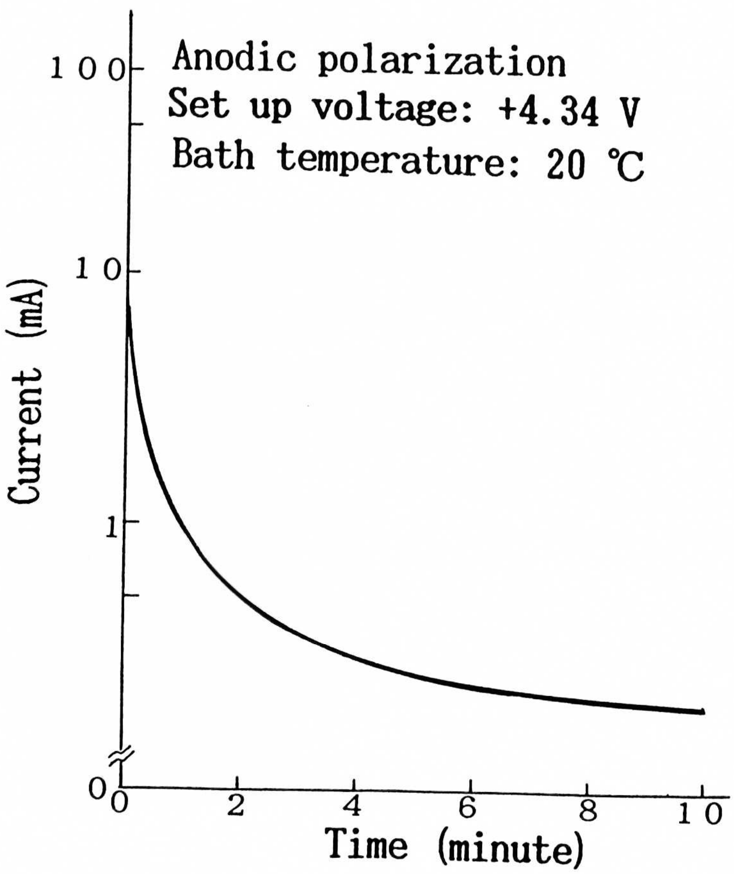

Fig.1 The change of anodic current in $KMno_4$ aqueous solution in the potentiostat.

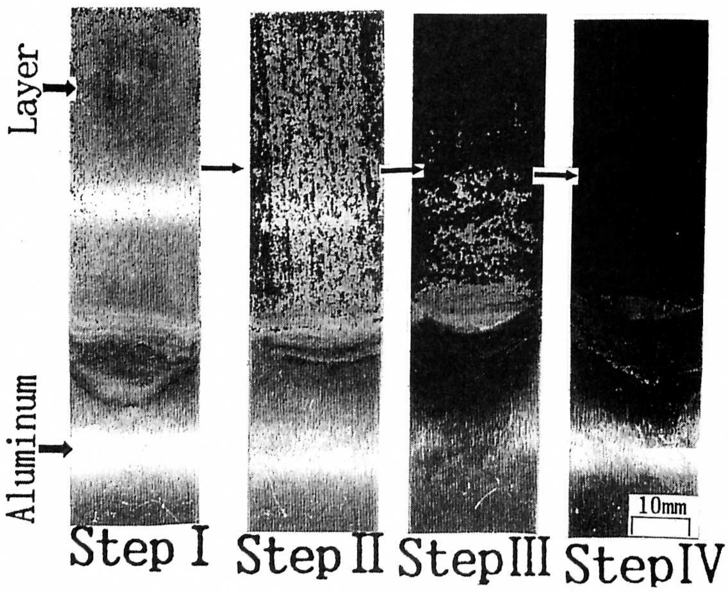

Fig. 2 The outsides of the layer in forming process in $KMnO_4$ aqueous solution.

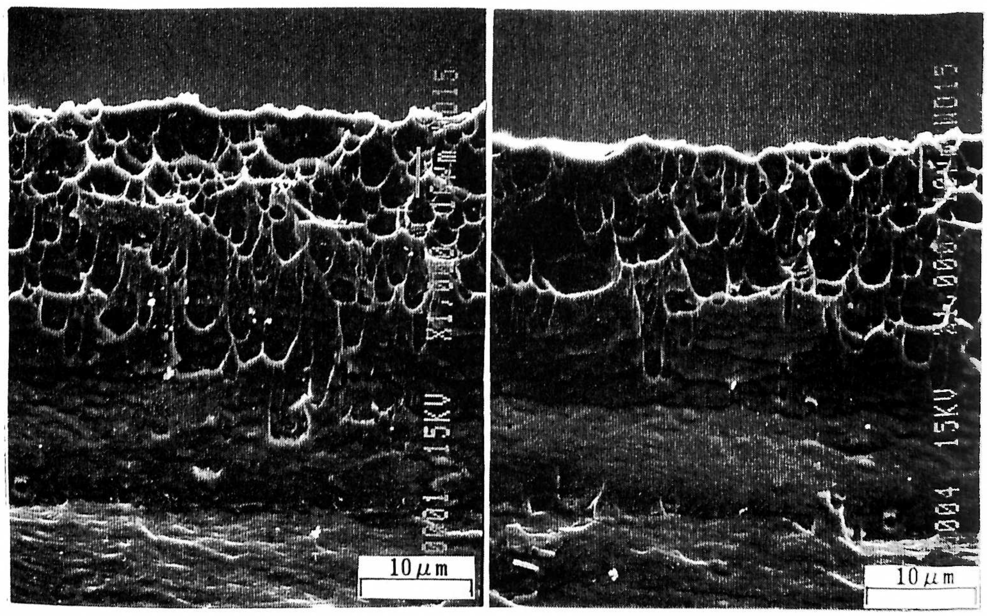

Fig. 3 The cross sections of the layer after anodizing for 30 minutes scanned by electron microscopy.

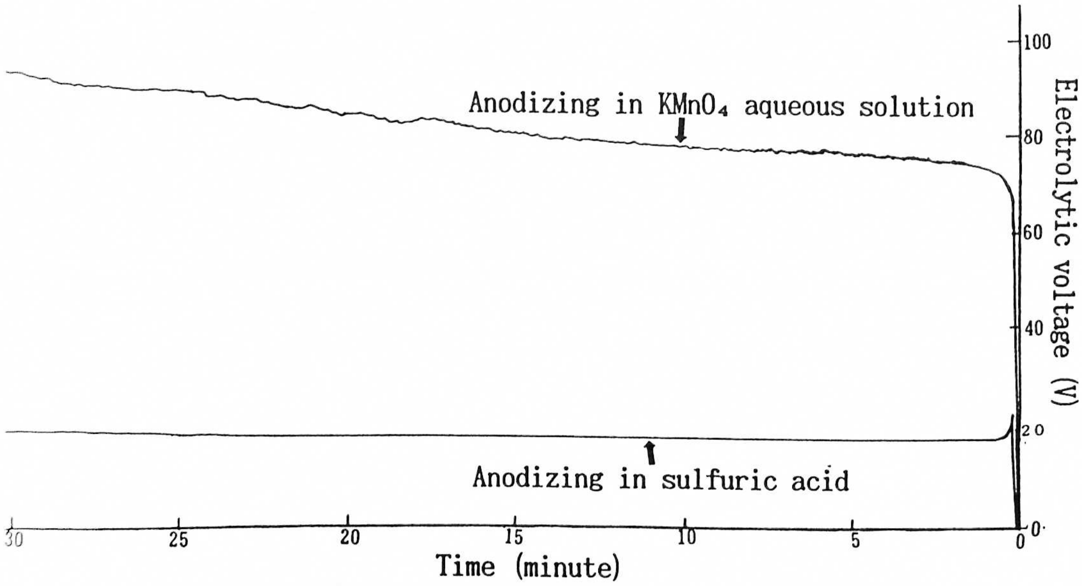

Fig. 4 Relationship between electrolytic voltage and time in $KMnO_4$ aqueous solution and sulfuric acid.

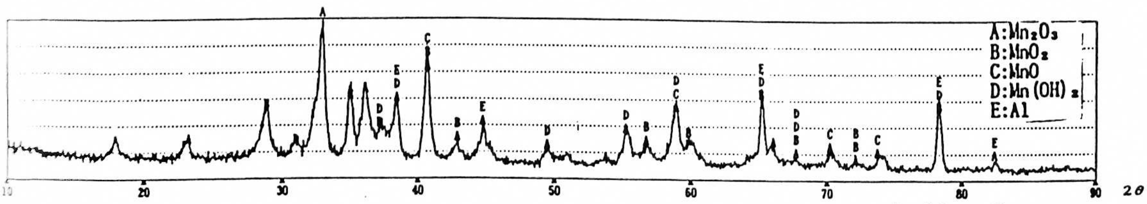

Fig. 5 Analysis of the composition of the layer by X-ray diffractometry.

A: Mn_2O_3
B: MnO_2
C: MnO
D: $Mn(OH)_2$
E: Al

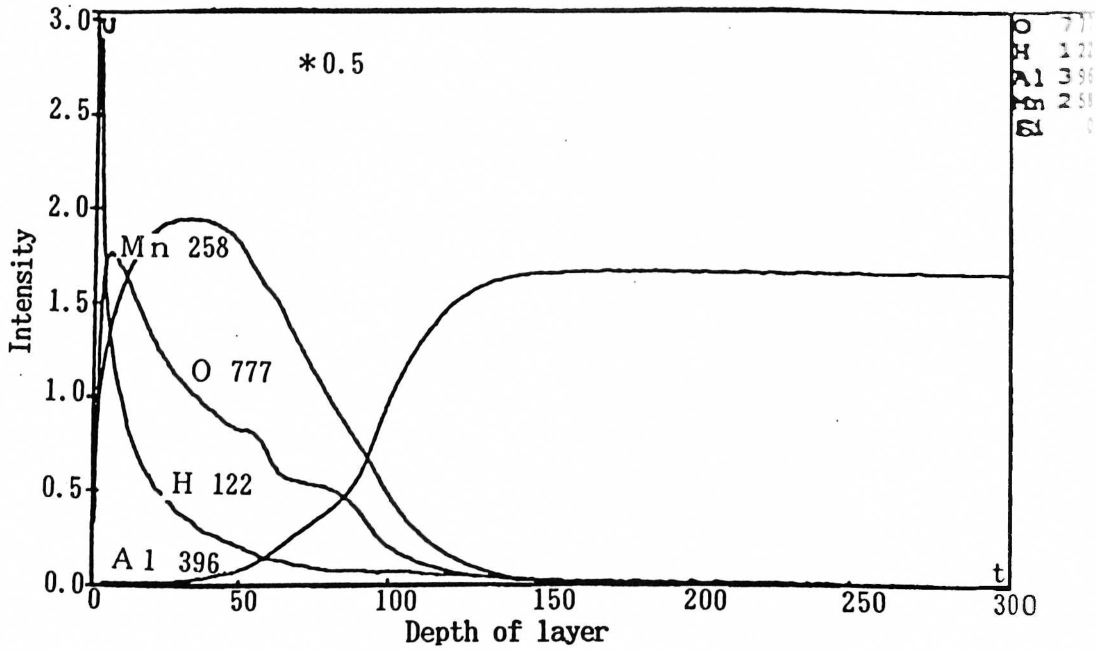

Fig.6 Analysis of the composition of the layer by plasma emission spectrosc

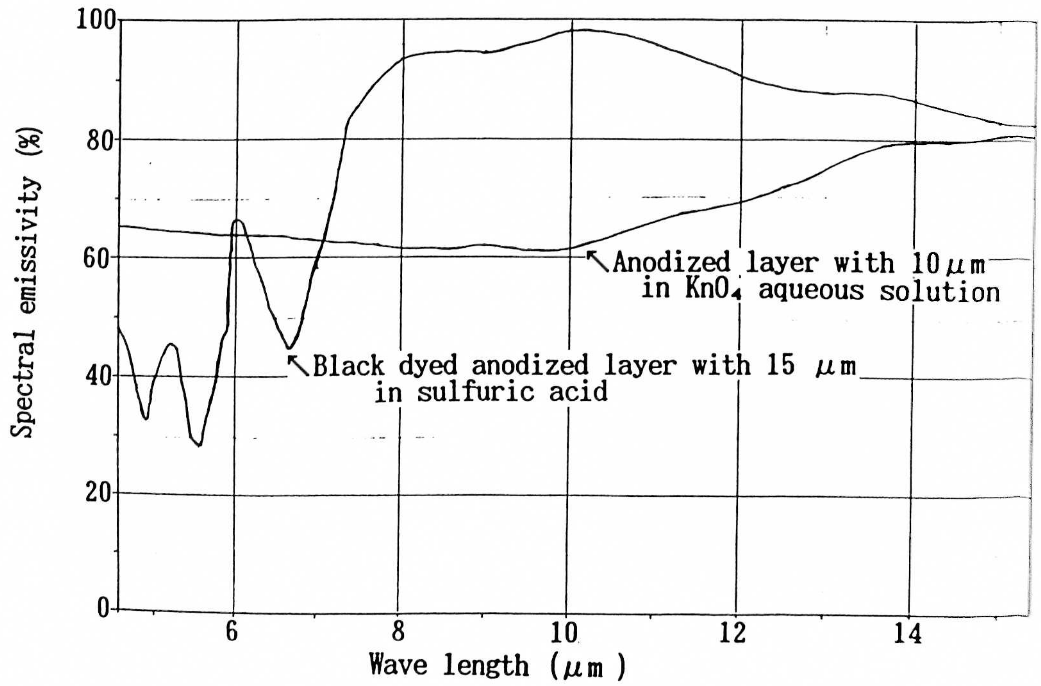

Fig.7 Analysis of the emissivity as far-infrared radiation at 200 ℃.