ELECTROCHEMICALLY PRODUCED ALUMINA AS TL DETECTOR

Margit OSVAY

Institute of Isotopes, 1525 Budapest, P.O.Box 77, Hungary

INTRODUCTION

What is thermoluminescence? The answer to this question can be found in the handbooks, e.g.: "Thermoluminescence is emission of light from an insulator or semiconductor when it is heated....Thermoluminescence is the thermally stimulated emission of light following the previous absorption of energy from radiation. In this statement can be found the three essential ingredients necessary for the production of thermoluminescence. Firstly, the material must be an insulator or semiconductor - metals do not exhibit luminescent properties" Š1Ć.

However we add that "metals", e.g. metal oxides šproduced by thermal or electrical methodsć on the surface of aluminium can also show thermoluminescent (TL) properties.

In our previous papers it had already been explained that electrochemically oxidized layers show high UV sensitivity and that its TL sensitivity increase proportionally with increasing the thickness of alumina layer and we also presented how to produce TL detectors using thermal or electrical oxidation on the surface of Al alloys Š2-3Ć.

The aim of the present work are as follows:

- to compare the TL properties of the electrochemically produced alumina (E-AlO) using various electrolyte
- to study the influence of the Mg content of alumina layer on the TL sensitivity of E-AlO
- to investigate the TL properties of electrochemically produced oxide layers (glow curve, reproducibility, linearity, fading)

EXPERIMENTAL

E-AlO detectors were prepared by electrochemical oxidation of three type of Al alloy sheets, in which the content of Mg increased: 1.5%, 3% and 4% (other additives were 0.3% Si, 0.15% Fe) and of fine Al ones. The electrolyte were following: sulphuric acid, "white oxide", oxalate acid and "hard oxide" (reducer).

The electrochemically oxidizes layers were produced at the Research Engineering and Prime Contracting Centre of the Hungarian Aluminium Corporation. In order to obtain various thickness alumina on the surface of AlMg alloy the times of oxidation were 15, 30, 45, 60, 75 and 90 min. As a result of this

the thickness of alumina layers was found 5.5, 12.5, 17.2, 25.2, 30.2 and 35.7 mm respectively. A special perforator was prepared to cut the sheets to get 9x1 mm^2 discs. Irradiation of the E-AlO detectors was carried out by ^{60}Co gamma rays. For TL investigations Harshaw 2000 AB TL reader was used. The heating rate was 5 °C/s, the maximum temperature of 300 °C was reached in each readout cycle. Five pieces of each type of detector were used for the comparative investigations. Since the individual TL response of the detectors varied, a selection was necessary to get TL sensitivity within 10%.

RESULTS AND DISCUSSION

The TL sensitivity of oxidized layers is more influenced by the type of electrolyte, than by the composition of alloy. I would like to emphasize some characteristics of only a few of those alumina layers investigated, which are of practical importances.

The comparative TL investigation on electrochemically produced alumina on Al alloys indicate the following:

- Glow curve exhibits generally one peak at about 250 °C, which is rather wide one. In case of hard oxide (produced in a reduction electrolyte) has been found a lower peak at 120 °C as well.
- Dose response of detectors in dose range 100 Gy-10 kGy are shown in Figure 1. For this comparison were used the some thickness of alumina on alloys and on fine Al. Figure shows, that the dose responses do not indicate a saturation tendency by increasing the dose in contrast to other TL detectors are available.

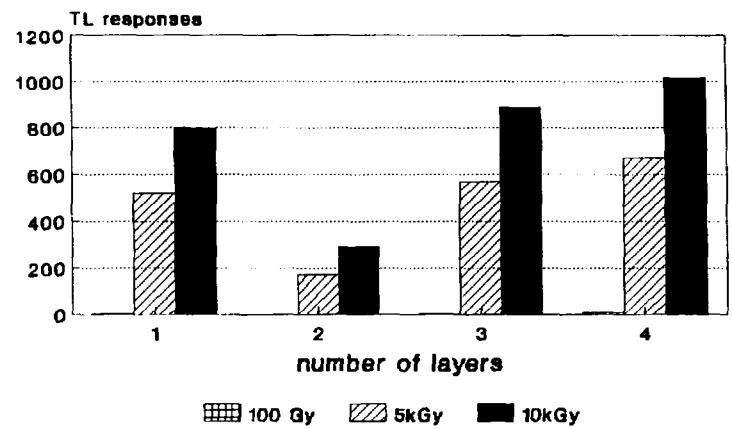

Fig.1. TL effect on E-AlO (using various electrolyte: 1-sulphuric acid; alloy, 2-white oxide; alloy, 3-hard oxide; alloy, 4-hard oxide on fine Al)

- Fine Al coated with alumina show generally lower sensitivity compared to on alloy one (eg. alumina on fine Al produced in sulphuric acid has 20 times lower sensitivity on fine Al compared to on alloy one).
- Hard oxide layer evolved in reducing electrolyte has rather different character compared to other alumina production investigated. The effect of reducing media seems to be very important: TL response of alumina has a ratio of 2 to 1 on fine Al and on alloy, respectively. This alumina shows the most high TL sensitivity among the layers investigated. The TL sensitivity of a relatively thin layer (the time of oxidation 30 min, thickness of alumina 17 mm) is nearly similar to Al_2O_3:Mg,Y (D-2) detectors developed for accidental dosimetry purpose Š4Ć.
- Organic electrolyte (oxalate acid) is not sufficient for producing alumina with good TL response.
- Fading property was also investigated at room temperature and at 50 °C. Twenty pieces of hard oxide alumina were irradiated by 150 mGy dose. Ten pieces of detectors were stored at room temperature and ten of them at 50 °C in an owen. The decrease of the measured mean TL responses after 5 days storage have been found to be 20% and 80% at 20 °C and 50 °C, respectively.
- TL sensitivity of alumina depends on the Mg content of the alloy. When the Mg changed from 1.5% to 3% in the alloy coated with alumina, the TL response increased by a factor of 2. Using higher concentration of Mg: 4%, the TL response decreased by a factor of 0.3 and also changed the shape of the glow curve compared to alloy containing 3% of Mg.

CONCLUSION

The results achieved on various E-AlO layers indicate, that the TL sensitivity is influenced by many parameters of electrochemical oxidation.

The electrochemical oxidation can be an easy and cheap method for preparing very thin TL detectors on the surface of Al or of Al alloys. One of the advantages properties of electrochemical produced layers is, that they serve a promising method to increase the measuring range of TL detectors above 10 kGy as well. Hard oxide layer has rather different TL character compared to other alumina production investigated. The measurements will be continued to get more information on the mechanism of TL of E-AlO layers.

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SUMMARY

The goal of this work was to compare the TL properties of various electrochemically produced alumina layers (E-AlO) in order to investigate the effect of the electrolyte and the Mg content on the alloys.

It has been found that the TL sensitivity of oxidised layers is more influenced by the type of electrolyte, than by the composition of alloy.

Hard oxide layer evolved in reduction electrolyte has rather different character compared to other alumina production investigated. The effect of reducing media seems to be very important during preparation of alumina layer.

One of the advantages properties of E-AlO is, that it serve a promising method to increase the measuring range of TL method above 10 kGy as well.