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METALLURGY AND CERAMICS (M-3679, 19th Ed., Suppl. 1)

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METALLOGRAPHIC TECHNIQUES FOR
BOND STUDY OF ALUMINUM-CLAD
NICKEL-PLATED URANIUM FUEL ELEMENTS

By
H. W. Woods

March 27, 1957

Atomic Energy Division
Sylvania Electric Products, Inc.
Bayside, New York

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H. W. Woods

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Various metallographic techniques were employed to determine the best method for the preparation of aluminum-clad, nickel-plated uranium fuel elements for bond studies. The quality of the final results and the speed of the preparation were the most important factors to be considered. The following procedure was found to yield the most advantageous results in the minimum amount of time.

An entire hollow core fuel element was cut lengthwise; half of the element was surface ground. Sections to be prepared for bond studies were cut from the top, middle, and bottom portions of the other half. The half of the element which was surface ground was then polished on emery papers 0 through 3/0, with kerosene as a lubricant. When a suitable polish was obtained, the entire slug was immersed in a 50 per cent solution of hydrochloric acid. This etching strength was used in order to obtain a contrast between the uranium core and the aluminum clad. Figure 1 is a photomicrograph of this section, showing an over-all longitudinal view of the element. The sections from the top, middle, and bottom of the element were cut to convenient sizes for hand polishing. The samples were not mounted in bakelite so that a maximum electrical contact for final electrolytic polishing could be maintained. The samples were ground on a 240 grit wet belt and then polished on emery papers 0 through 4/0 with kerosene as a lubricant. Owing to the differences in hardness of the aluminum, uranium, and the bonded areas, the samples were polished in one direction across the interface on both the papers and the rotating lap. Since uranium is much harder than aluminum, if the samples were rotated during polishing, both the bonded and the uranium areas would stand in relief from the aluminum. This effect is minimized to a great extent by polishing in one direction only -- across the uranium to the aluminum.

These samples were then polished for less than 60 seconds on a microcloth with eight-micron Diamet-Hyprez as the abrasive and kerosene as the lubricant. The samples were then washed in alcohol and dried. The diamond polish removes most of the disturbed metal and also levels the area around the bonded interface.

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The samples were then electrolytically polished on the Disa Electrolytic Polishing Unit (Fig. 2) distributed by the Udderholm Corporation of America. An electrolyte called Disa-Electrolyte A2 containing 700 cc. ethyl alcohol, 120 cc. water, 78 cc. of 60 per cent perchloric acid, and 100 cc. Buthl "Cellosolve" was used for the electrolytic polishing of both the uranium and the aluminum. A polishing potential of 50 volts and a current density of 13 amperes was used for five seconds. The samples were thoroughly washed and dried. The diffusion zones were clearly defined by electrolytic polishing, but in order to define more clearly the extent of the remaining free nickel, the samples were etched with concentrated nitric acid by swabbing for one second. This acid attacks only the free nickel.

Photomicrographs were taken of the bonded interfaces. Figs. 3 and 4 show the zones on the top and the bottom of the element. Figs. 5 and 6, taken from the middle section, show the zones on the outside and the inside of the element. Fig. 7 shows the aluminum-to-aluminum (or cap-to-can) bond as electrolytically polished.

Several other techniques were tried in this laboratory with varying degrees of success. By far, the method just described produced the best and the most dependable results, and is, therefore, recommended for use in future bond studies of aluminum-clad, nickel-plated uranium.

Plate No. 14947

Fig. 1 - Longitudinal View of Element.

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Fig. 2 - Disa Electrolytic Polishing Unit.

Plate No. 14952

500X

Fig. 3 - Uranium, Nickel, Aluminum Zones from Top of Element.
(Longitudinal Section)

Plate No. 14953

500X

Fig. 4 - Uranium, Nickel, Aluminum Zones from Bottom of Element.
(Longitudinal Section)

Plate No. 14954

500X

Fig. 5 - Uranium, Nickel, Aluminum Zones from Inside of Element.
(Longitudinal Section)

Plate No. 14951

500X

Fig. 6 - Uranium, Nickel, Aluminum Zones from Outside of Element.
(Longitudinal Section)

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Plate No. 14948

500X

Fig. 7 - Aluminum Cap-to-Can Bond.

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