SPARK COUNTING TECHNIQUE WITH AN ALUMINIUM OXIDE FILM

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We have tried to use aluminium dioxide film as neutron detector film with spark counter. The merits of this method are that 1) aluminium dioxide is good insulator, 2) arbitrary thickness of the film can be made, 3) chemical etching of the thin film is dispensable.
Preparation of aluminium dioxide film: An aluminium plate (30 x 40 x 0.5 mm^3) was treated with dilute NaOH solution and HNO_3 solution before electrolysis. A nickel plate as a cathode and the aluminium plate as an anode were immersed in 15% sulfuric acid solution for oxidation of aluminium. Electric current density was 10～20 mA/cm^2 and the temperature was 12 ^oC. Electrolysis was made for 10～30 minutes. After electrolysis aluminium plate was rinsed with distilled water and kept in boiling water for about 30 minutes for hole sealing. Thickness of aluminium dioxide film was calculated with the weight of aluminium plate before and after electrolysis.
Neutron irradiation: An aluminium dioxide film deposited on an aluminium plate was attached with a 100 μg uranium target of 2.4 cm diameter electrodeposited on a stainless steel plate. This pair was fixed with scotch tape and irradiated with thermal neutron flux (5.7×10^5 n/cm^2.sec) produced by Kinki University's reactor UTR-Kinki (1 watt).
Spark counting: After neutron irradiation the aluminium dioxide plate was separated from uranium target plate and attached with an aluminized polyester sheet. As shown in Fig.1 high voltage was applied between the aluminized sheet electrode (cathode) and the aluminium plate electrode (anode),which was the base of aluminium dioxide film. Sparked pulses were counted with a usual scaler.
Results: Aluminium dioxide thickness depends upon time and temperature of electrolysis and sealing time.
Time of electrolysis: The relation between time of electrolysis and thickness of aluminium dioxide deposited at 12 ^oC is shown in Fig.2. Aluminium dioxide thickness was proportional to the time of

electrolysis until 60 minutes. Thereafter it gradually reached saturation near 120 minutes.

Temperature of electrolysis: The relation between temperature of electrolysis and thickness of deposited aluminium dioxide at electric current density of 20 mA/cm^2 for 30 minutes at $12 \sim 30\ ^{o}C$ is shown in Fig.3. The thickness of aluminium dioxide deposited reached $7 \sim 8\ \mu m$ until 20 ^{o}C and it rapidly decreased as temperature rose. Above 30 ^{o}C aluminium dioxide film once formed was solved into the solution.

Sealing: After electrolysis aluminium dioxide was immersed in boiling water for hole sealing. Thickness of aluminium dioxide formed seemed to be independent to sealing time. The thickness increased about 1.5 times that before sealing as shown in Fig.4.

Electric resistance: The relation between electric resistance of aluminium dioxide film and sealing time is shown in Fig.5. Water vapour (100 ^{o}C) sealing instead of boiling water was also examined. Electric resistance of aluminium dioxide depended on the thickness of the film. Above 7 μm of thickness electric resistance was almost constant value of 15 MΩ. Circuit tester (MΩ range) was used for measuring electric resistances. The infinity sign "∞" in the ordinate in Fig.5 means no deflection of indicating needle.

Sparking characteristics: Sparking characteristics, the relation between applied voltage and spark counts, were examined for aluminium dioxide films of several thickness as shown in Fig.6. The figures in parentheses show aluminium dioxide thickness in μm. High voltage was changed from 300 to 500 volts. There were short plateaus at $410 \sim 430$ volts. Spark counts increased as thickness of aluminium dioxide film decreased. Higher voltages than plateau voltages were liable to cause multiple sparks.

Circuit constants: Sparking characteristics were investigated at various electric resistances and capacities in the sparking circuit in Fig.1. Fig.7 and Fig.8 show the relations between spark counts vs. electric resistances and that between spark counts vs.capacities, respectively, at applied voltage of 420 volts. Three curves correspond to three different uranium amounts of targets attached to aluminium dioxide films of about the same thickness at neutron irradiation. From these results 250 kΩ and 200 pF were adopted as suitable resistance and capacity for routine measurements.

Spark counts vs. thickness of aluminium dioxide film: The relation between spark counts and thickness of aluminium dioxide film is shown in Fig.9. Dotted line shows spark counts of a detector irradiated without uranium target. No spark counts were observed in case of the thickness above 7.3 μm. Spark counts increased as the thickness decreased, however, if aluminium dioxide film was too thin, minute scars on the surface of the film were liable to spark.

Linearity: The relation between spark counts and uranium amounts of targets used at neutron irradiation attached with aluminium dioxide detector of about the same thickness is shown in Fig.10. Spark counting efficiency was calculated to be about 8.5%, which was lower than that of usual polycarbonate detectors.

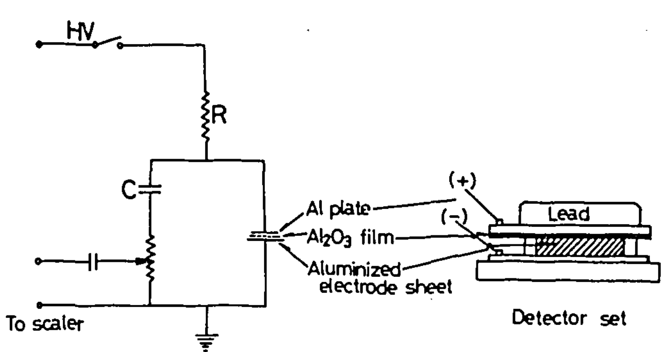

Fig.1 Circuit and arrangement of a spark counter.

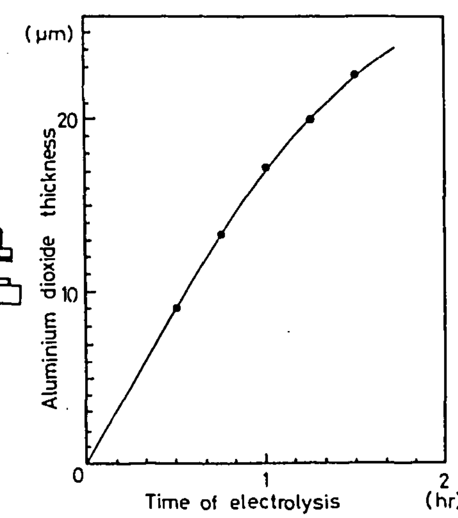

Fig.2 The relation between aluminium dioxide thickness and time of electrolysis.

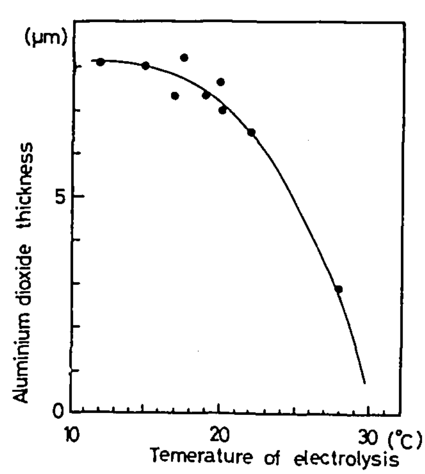

Fig.3 The relation between aluminium dioxide thickness and temperature of electrolysis.

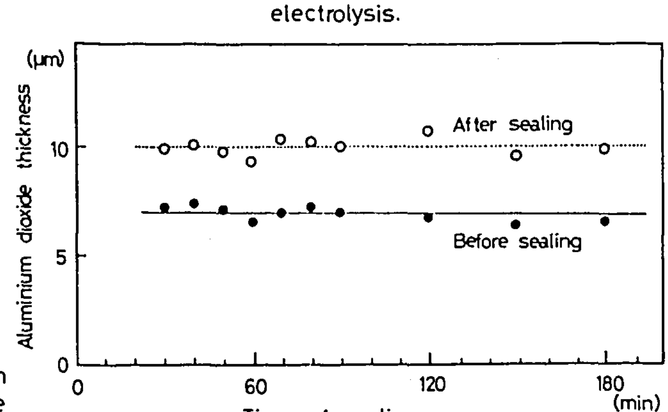

Fig.4 Variation of aluminium dioxide thickness before and after sealing.

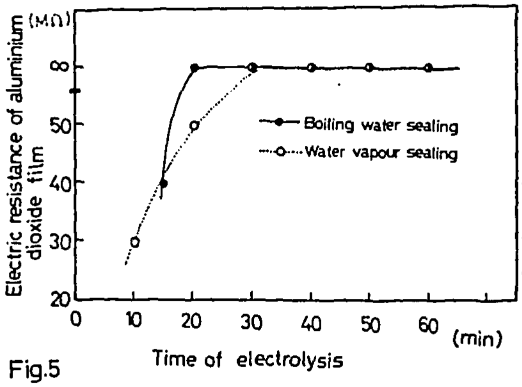

Fig.5
The relation between electric resistance of aluminium dioxide and time of electrolysis.

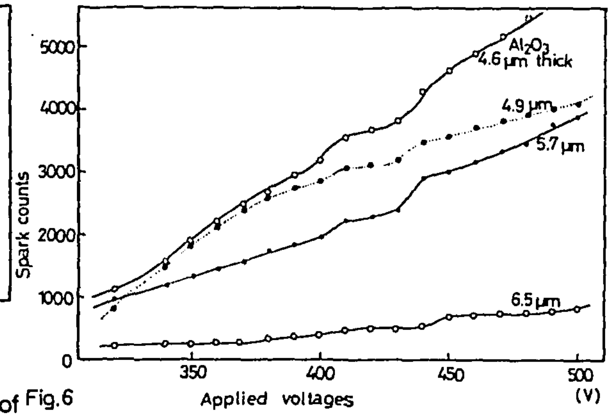

Fig.6
The relation between spark counts and applied voltages.

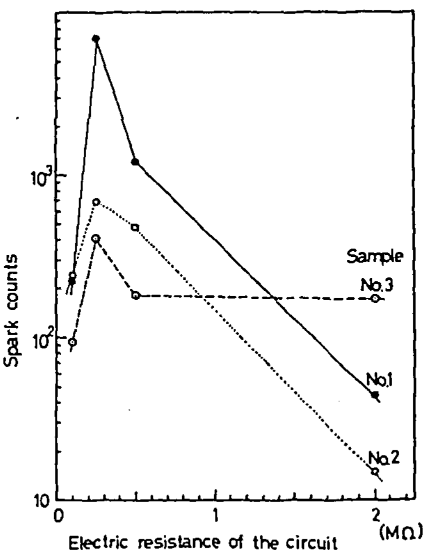

Fig.7 The relation between spark counts and electric resistance in sparking circuit.

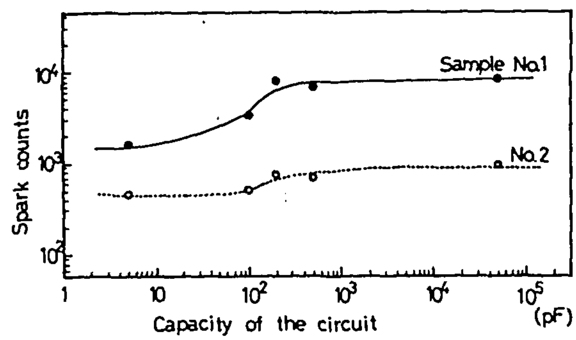

Fig.8 The relation between spark counts and capacity in sparking circuit.

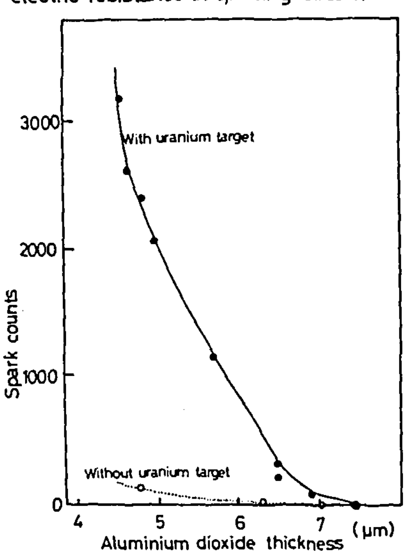

Fig.9 The relation between spark counts and thickness of aluminium dioxide.

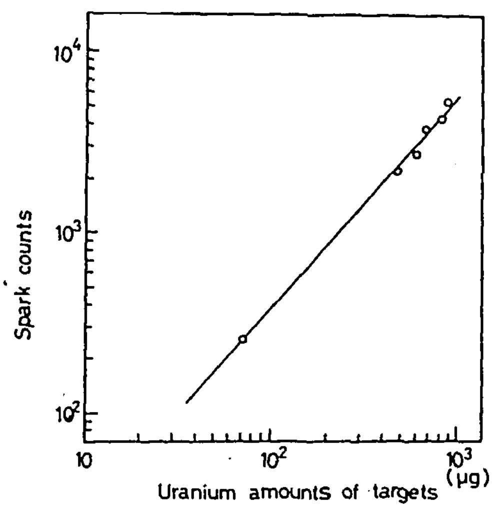

Fig.10 The relation between spark counts and uranium amounts of targets attached with aluminium dioxide detector.