Development of a Recycling Process for Tantalum from Capacitor Scraps

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Introduction
Features of Ta capacitor

- Largest capacity per unit volume among capacitors.
- High thermal stability.

Properties of tantalum

- Density: 16.65 g/cm³
- Melting point: 2980 °C
- High corrosive resistance
- Ta₂O₅ is a stable & high-performance dielectric material.

Suitable material for capacitor.

Structure of the electrode of Ta capacitor

- Ta powder (Anode) Ta₂O₅ (Dielectric)
- Ta₂O₅, MnO₂ (Cathode)

Demand for tantalum

Table. Production of tantalum & its Price

Production 2,300 ton Ta
Ta powder for capacitor 1,400 ton Ta
Price (approximately) ~700 $/kg Ta
Tantalum is an expensive metal and its production is significantly limited. Major application of tantalum is capacitor.

The development of high-performance electric devices in the last 10 years.

Demand and production of high-performance tantalum capacitor is accelerated.

In 2000, the price of tantalum ore rose suddenly by 6 times

Maker of Ta capacitor encountered material crisis.

Purpose of this study

- A considerable amount of off-spec capacitor is generated in the production of capacitor.
- There is no effective recycling process.
- The demand for Ta is very large, and production volume is increasing.

Recovery Process

- Sintered tantalum electrodes are tightly covered in epoxy resin.
- After oxidation, components of the capacitor were disconnected. Ta electrodes retained its shape, on the other hand, epoxy resin became SiO₂ powder.

The sample was sifted to remove SiO₂.

Analytical results

The purity of Ta obtained by this process was approximately 99 mass%.

The yield of the process was 90 ~ 92 %.

Future work

To develop an effective purification process of the obtained Ta, chlorination of the Ta / Ta₂O₅ by using scrap FeCl₃ generated from the Kroll Process is currently under investigations.

As the chloride wastes from the Kroll Process are currently discarded, this scrap combination process has large potential both for cost reduction and resource saving.

The Kroll process generates a large amount of chloride scrap (mainly FeCl₃) from the TaCl₅. Employing the chloride scrap (FeCl₃) as a source of chlorine.

By distillation, high purity tantalum chloride can be obtained.

Flowchart of this Study

Ta Capacitor Scrap
O₂
Ta₂O₅, Ta, SiO₂, MgO
Magnetic Separation
Fe, Ni
Mg
Ta, Ta₂O₅
Ta₂O₅ + 5 Mg → 2 Ta + 5 MgO
Reduce
S
TaO₂, Ta₂O₅
Leaching
S
TaO₂, Ta₂O₅
Coated Ta
Ta, MgO, Mg
Acid
Leaching
Ta, Ta₂O₅
TaO₂, Ta₂O₅
Sponge titanium
Mg
Stainless steel vessel
Reduction temp: 1273 K
Reduction time: 6 hours
Fig. The container for magnesiothermic reduction

Oxidation

Magnetic separation

TaO₂ + Ta₂O₅
TaO₂, Ta₂O₅
Leaching
TaO₂, Ta₂O₅
Ta powder for capacitor
1,400 ton Ta
Price (approximately)
~700 $/kg Ta
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Preliminary experiments

Oxidation of each components of Ta capacitor

Fireproof epoxy resin:
SiO₂ powder compounded resin
Sintered tantalum electrode:
Content of Ta is 90% or higher
Terminal: Ta, Fe, Cu

Oxidation process at 773~1273 K was investigated to recover sintered Ta electrode.

The chemical separation between SiO₂ and tantalum oxide is difficult.

The mechanical separation was found to be both effective and efficient.

Conclusion

- Sintered tantalum electrodes in the capacitor scrap were recovered by means of mechanical separation.
- High purity tantalum oxide powder was obtained after chemical treatment.
- After magnesiothermic reduction of the tantalum oxide, tantalum powder with 99 mass% purity was obtained.