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Oxygen Evolution Reaction for Ta Compound Films Prepared by Reaction Sputtering with Resintering

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Introduction

Water electrolysis will be played important role in the society of "Green hydrogen"[1] which is produced from the renewable energies.

When the electrolyzer was operated with the fluctuant electricity based from the renewable energy such as wind and solar power, the stack efficiency became lower than that was operated the high rated current[2]. The fluctuant electrode potential is also very serve condition for Therefore, the electrocatalyst of water electrolysis with high stability should be required for the development of "Green hydrogen".

Since the Ta oxide-based compounds which have the catalytic activity for oxygen reduction reaction in an acidic solution[3], we have tried to apply them to electrocatalyst for oxygen evolution reaction (OER). However, the catalytic activity of Ta oxide-based compounds for the OER was very low when it was prepared by reactive sputtering with TaC target [4].

In this study, in order to improve the OER activity, we have investigated the effect of the resintering under vacuum at high temperature on the OER activities of Ta compound film prepared by reactive sputtering.

Experimental

Ta compound thin film on an etched Ti rod was prepared by the reactive sputtering with Ta metal as target in the temperature range from 298 to 873 K, while other conditions were the constant under the partial pressure of oxygen (p_{O_2}) and nitrogen (p_{N_2}) of 6 mPa and 0.22 Pa with Ar balance. After the sputtering, the film was resinterd in the temperature range from 873 to 1173 K under vacuum.

Electrochemical measurements were examined in 0.1 M (= mol dm^{-3}) H_2SO_4 at 303 K. The working electrode was the Ta compound thin film on Ti rod. A carbon plate was used as a counter electrode. The reversible hydrogen electrode (RHE) was used as a reference electrode. Cyclic voltammometry (CV) and slow-scan voltammometry (SSV) were performed under nitrogen atmosphere.

Results and discussion

Figure 1 shows the SSV of Ta compound film prepared by sputtering at 873 K with and without the resintering. The current density was based on geometric surface area. The OER current densities of Ta compound film prepared by the sputtering with resintering were two times higher than that by sputtering without resintering. According to CV from 0.3 to 0.8 V vs. RHE, the anodic electric charge (Q_A) on the film prepared by sputtering and resintering was larger than that by sputtering without resintering. Therefore, the resintering treatment during film fabrication was effective for the Ta compound film to increase the surface area.

Figure 2 shows the SSV of Ta compound film prepared at various sputtering with resintering temperature. The parameters of pseudo-effective current density: $i^*(= I \cdot Q_A^{-1})$ was determined from the current (I) divided by the Q_A of electric double layer change. The i^* of Ta compound film was the largest for the sputtering at 873 K with resintering at 873 K in all of this study. Therefore, the Ta compound film prepared by sputtering at 873 K with resintering at 873 K had not only larger surface area but also higher pseudo-specific activity for the OER than that prepared by sputtering without resintering.

Reference

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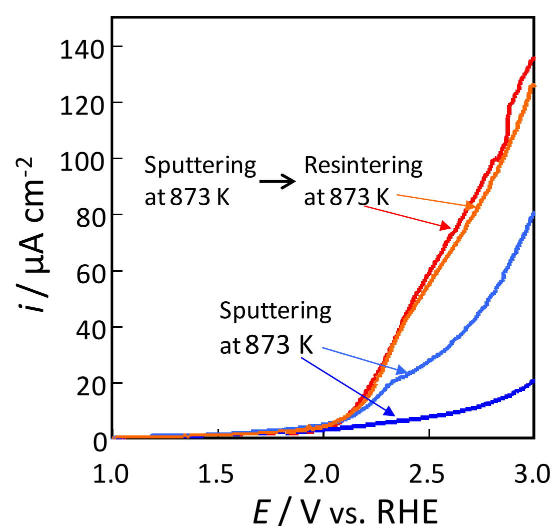

Fig. 1 Slow scan voltammograms based on geometric surface area with scan rate of 5.0 mV s^{-1} on Ta compound films which were prepared at 873 K of sputtering temperature.

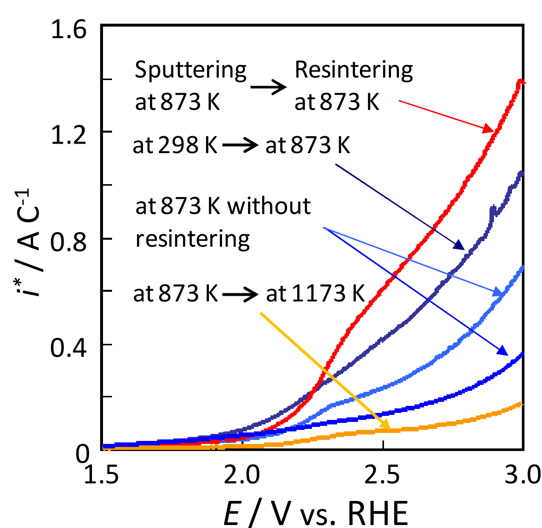

Fig. 2 Slow scan voltammograms based on pseudo-effective surface area with scan rate of 5.0 mV s^{-1} on Ta compound films which were prepared at various sputtering and resintering temperature.