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Conductivity Response of Palladium Semicontinuous Film Deposited using Piezoelectric Resonance Method to Hydrogen

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Background, Motivation and Objective

When metallic material is deposited on substrate, morphology of the deposited material changes from island structure (isolated clusters) to continuous film. Around the morphological transition, semicontinuous film is formed, in which isolated and connected clusters coexist. When the palladium semicontinuous film is exposed to hydrogen, hydrogen is absorbed in the palladium clusters, and lattice expansion occurs. Then, some of clusters contact each other, and the electrical resistance decreases. This behavior is applicable for hydrogen sensing, however deposition of the semicontinuous film is quite difficult, because observation of the morphological change during deposition is difficult. We solve this problem using the piezoelectric resonance method, and evaluate the response of the semicontinuous films to hydrogen.

Statement of Contribution/Methods

In the piezoelectric resonance method, resonant vibration of a piezoelectric material placed beneath the substrate is monitored. When palladium is deposited on the top surface of substrate, electrical current is caused by the electric field generated by the vibrating piezoelectric material, and a part of vibrational energy is used for it. Because the energy loss becomes maximum around the transition from the discontinuous to continuous structure, morphological change is detectable by monitoring the attenuation of the vibration. Using this method, discontinuous, semicontinuous, and continuous films were fabricated. The films were then exposed to hydrogen, and changes in the electrical resistance were measured.

Results/Discussion

Among the films, the semicontinuous film showed the largest change in the electrical resistance. Figure 1 shows the representative change in the resistance of a semicontinuous film at 100-ppm hydrogen. The change ratio was larger than that reported in the previous study, and hydrogen below 1 ppm was detectable. In contrast, the change ratio in the discontinuous and continuous film was small, because the hydrogen exposure could not close the gap or most of the clusters had been already connected each other, respectively. These results indicate that the semicontinuous film is suitable for hydrogen sensing, and the response can be controlled using the piezoelectric resonance method.

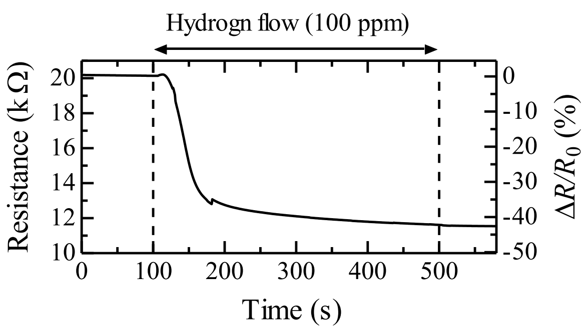

Figure 1 Change in the electrical resistance of the semicontinuous film at hydrogen concentration of 100 ppm.