Thickness Distribution Calculation of Electroplating to a Resistive Electrode - Electrolytic Copper Plating to Electroless Copper Plating

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We have developed and sold the current distribution analysis program “Electroplating Pilot Systems (EPPS)” of electrochemical cells. The last lecture convention reported the effect which included the iteration method high-speed solution of the finite element method in the analysis program. However, if the iteration method high-speed solution was used for the analysis of a resistive electrode, convergence was difficult and great computation time was required. In order to analyze a resistive electrode efficiently, the direct method high-speed solution without convergence calculation was incorporated. As a result, analysis of a three dimension resistive electrode has made for a short time. The thickness distribution of electroplating to electroless plating on plastic can be calculated, and analysis can be utilized for examination of the position of current supplying points.

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Introduction

When the iteration method of the finite element method was used for the analysis of a resistive electrode, convergence was very poor and extreme computation time was required. As compared with the iteration method, direct method generally needs great computation time, and consumes many memories. However, it is effective if convergence uses for the analysis of a difficult problem, since there is no convergence calculation. Furthermore, when carrying out mesh creation, in order to generate easily the element equivalent to the resistive electrode of a thin film, the sheet resistive element was devised and incorporated. A plastic carries out electroless plating and it is made for electricity to flow through it. When performing electroplating to this, the design of the current supplying points is important. In this report, calculation and experimental result of thickness distribution were compered, when carrying out electrolytic copper plating on electroless copper plating of ABS resin.

Plating Experiment

The plating test coupon was ABS resin with a size of 153x204mm, and a thickness of 3mm. This test coupon was plated with a commercial electroless copper bath. The average deposit thickness of every 5mm along the central part of the long direction measured by Fluorescent X-ray coating thickness gauge was 0.158 μm, and sheet resistance values were 0.538ohm/□. Electroplating of the test coupon was carried out in the cell shown in Fig.1. The anode has been arranged in one side of the cell and plated on one side. The supplying point of the current of cathode is the center of the upper end. The backside of the test coupon was masked by tape. The conditions of electrolytic copper plating are shown in Table 1. In order to investigate time change and the thickness distribution of plating, these were plated with times of 30 and 120sec. The thickness distribution of the electrolytic copper plating film was measured by Fluorescent X-ray coating thickness gauge, and subtracted the deposit thickness of electroless copper plating from measurement deposit thickness. Deposit thickness was measured in 5mm pitch in the lower part from the supplying point of current.

Thickness Distribution Calculation

From the symmetry of the plating cell, one half of the portions of the cell were made into the analysis area, and were modeled. The mesh division figure is shown in Fig.2. The element is a tetrahedron. The sizes of the model are 46,213 nodes and 262,086 elements (Fig. 2). The composition of the element arranges the film element of the plane element same on the sheet resistive element which is a plane element, and an overpotential element (Fig. 3). The element of the plating solution which is a solid element is connected to this overpotential element. Each measurement data was used for the electrical conductivity and the polarization of the plating solution, and the electrical conductivity of the copper plating film. The cathode polarization of a plating solution is shown in Fig.4, and the electrical conductivity of an electrolytic copper plating film is shown in Fig.5. It is necessary to pursue the growth process of plating deposit thickness in the analysis of a resistive electrode. The time which calculated deposit thickness is 1, 2, 4, 8, 15, 30, 60, 120, 240, 480, 960, and 1,490sec. When CPU of a personal computer was Xeon 3.4GHz which carries memory 2GB, the computation time to the last step was 8,566sec. The contour figure of the potential after plating start 1sec is shown in Fig.6. It turns out that potential is low at the supplying point of current at the time of a plating start, and the potential difference in cathode is large. The contour figure of the current density of cathode is shown in Fig.7. Although current density is high in early stages of plating at the supplying point of current, it is subsequently eased with advance of plating and the concentration part of current becomes corners. The contour figure of the thickness distribution after 30 and 120sec is shown in Fig.8. Although deposit thickness is so thick that it is close to the supplying point of current after 30sec, also in a lower corner deposit thickness becomes thick after 120sec.

Comparison of Calculation and Experimental Result

The graph which compared the thickness distribution of the calculated value and experimental value after 30s and 120s is shown in Fig.9. Both were well in agreement in both times. The graph which compared time change of the cell voltage from plating start to after 120s is shown in Fig.10. The calculated value and the experimental value of cell voltage corresponded mostly.

Conclusion

By introduction of direct method high-speed solution and sheet resistive element, the analysis of a three dimensions resistive electrode problem was attained practical. When the thickness distribution of electrolytic copper plating on electroless copper plating was compared, the calculated value and the experimental value were well in agreement. Furthermore, time change of cell voltage was also well in agreement. Also, analysis can be used for examination of the current supplying point of plastic plating.

References

1. K. Ohara, H. Hatase, and T. Sakurai; Hyomen Gijutsu, 47, 751(1996)
2. K. Ohara; Hyomen Gijutsu, 50, 416 (1999)

Table Condition of copper sulfate bath

Copper sulfuric 5H2O	200g/L	Temperature	25
Sulfuric acid	50g/L	Current density	3.0A/dm2
Chlorine	70ppm		
Additive	Very small		

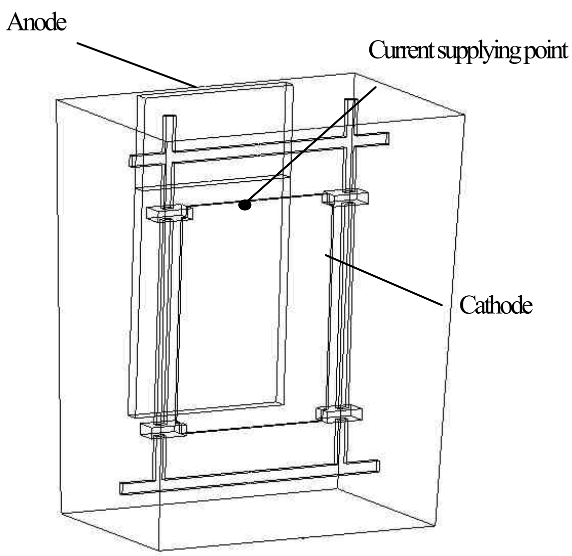


Fig. 1 Plating cell

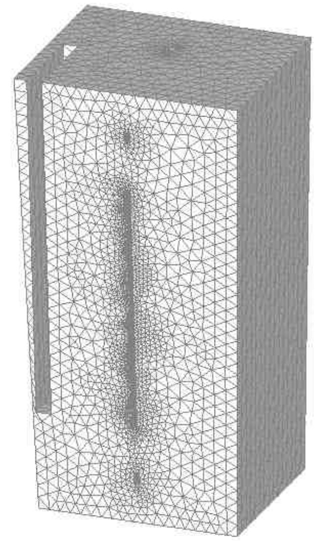


Fig. 2 Mesh division figure

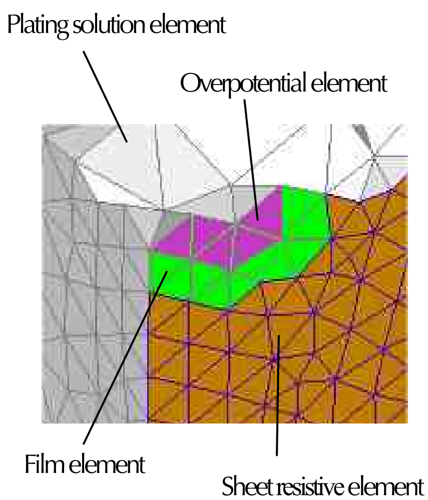


Fig. 3 Composition of element

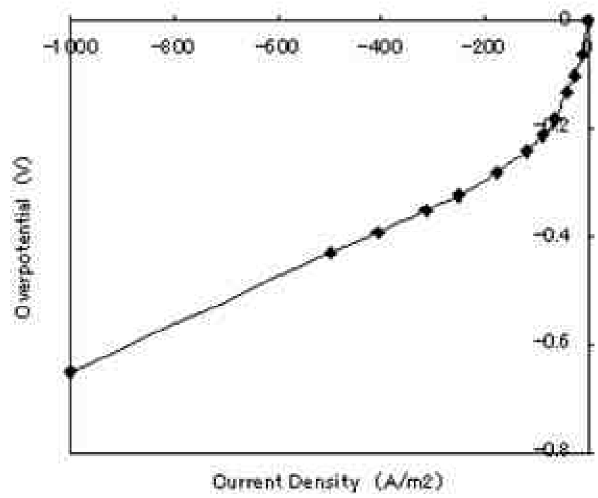


Fig. 4 Cathode polarization

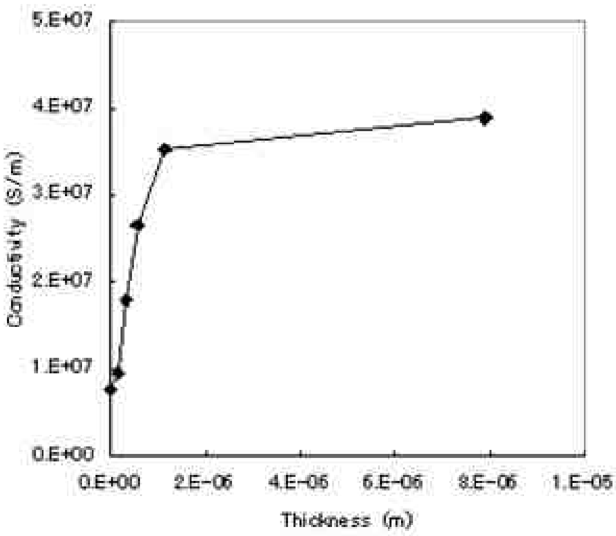


Fig. 5 electrical conductivity
of an electrolytic copper plating film

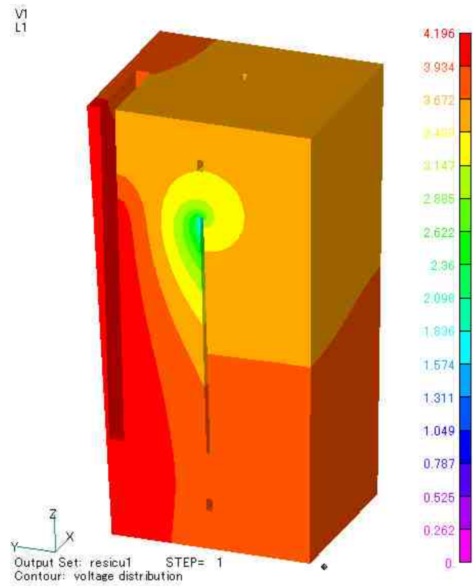
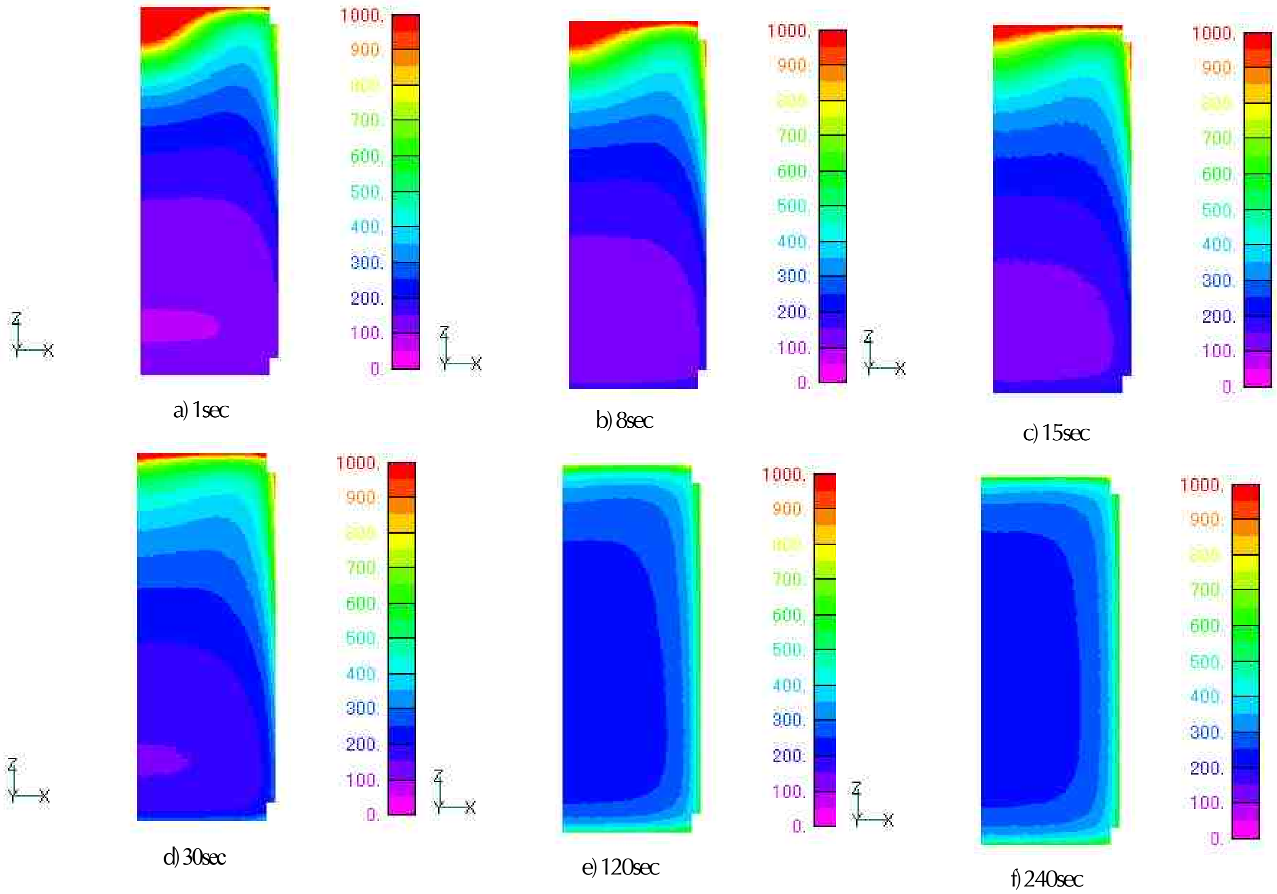


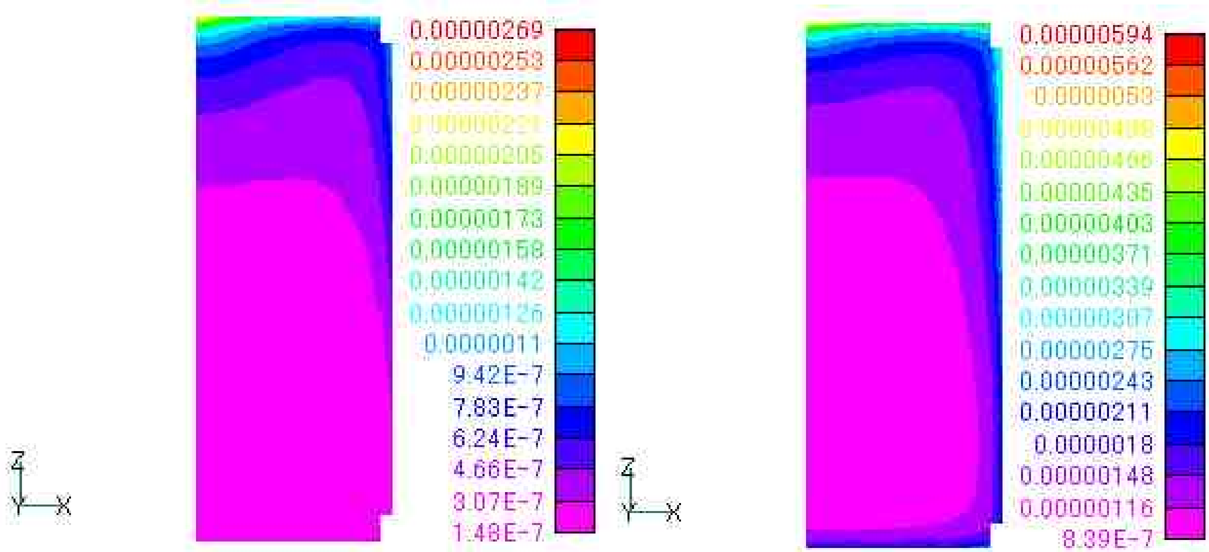
Fig. 6 Contour plot of current distribution



a) 1sec b) 8sec c) 15sec

d) 30sec e) 120sec f) 240sec

Fig.7 Contour plot of current distribution



a) 30s b) 120s

Fig.8 Contour plot of thickness distribution

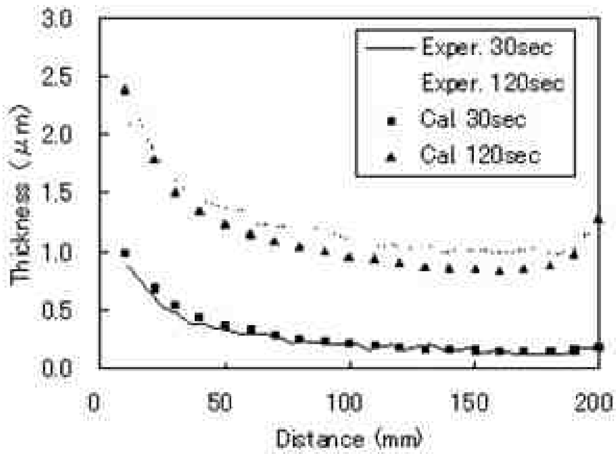


Fig. 9 Comparison of deposit thickness after 30 and 120sec

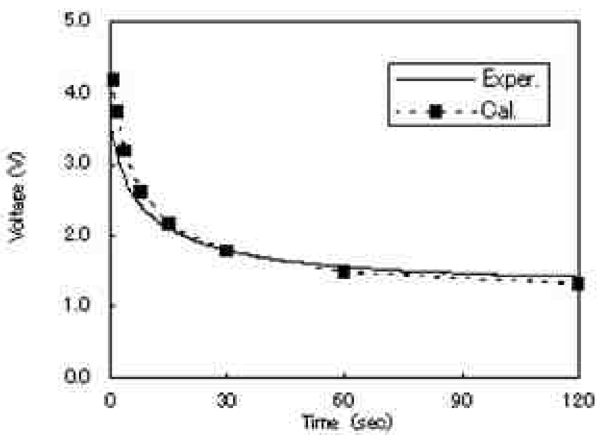


Fig. 10 Comparison of cell voltage