Dynamic Electrochemical Measurement System "d-EC" for Fundamental CMP Study

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1. Introduction

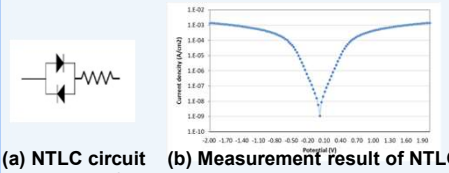
Advanced design on slurries has been required for chemical mechanical polishing (CMP) of metal interconnect. Tafel plot evaluation based on electrochemical measurement using potentiostat system is known as an effective analysis method of metal corrosion. However, the evaluation in the most cases is conducted in static condition because the dynamic measurement requires special electrode like a rotational working electrode. Furthermore, electrochemical measurement itself has been thought to be a difficult system for some engineers because measurement data is easy to affected by environmental noise and contact situation of electrodes. From these reason, development of dynamic electrochemical measurement system that is easy to handle even in the field and facilitates has been desired.

"d=EC" in shield box

Doi Laboratory Inc.

2. Configuration of "d-EC" system

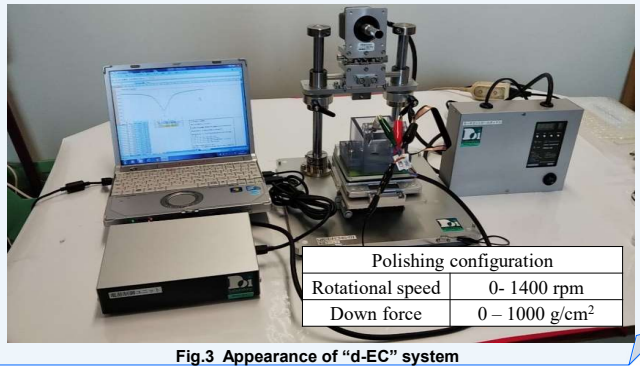
We developed dynamic electrochemical measurement system (d-EC: Doi Laboratory Inc.,) which have two unique characteristics. One is **flip-up polishing unit** which can apply wide ranges of rotational speed and down force pressure. The other is "novel test-load circuit (NTLC)" which can obtain "Tafel like" plot without connecting any electrode. By using NTLC, we can know easily whether electric measurement system works correctly or not and environmental noise effect.



(a) NTLC circuit (b) Measurement result of NTLC

Fig.1 NTLC circuit and its measurement result

Fig.2 Flip-up polishing system



Polishing configuration	
Rotational speed	0- 1400 rpm
Down force	0 – 1000 g/cm^2

Fig.3 Appearance of "d-EC" system

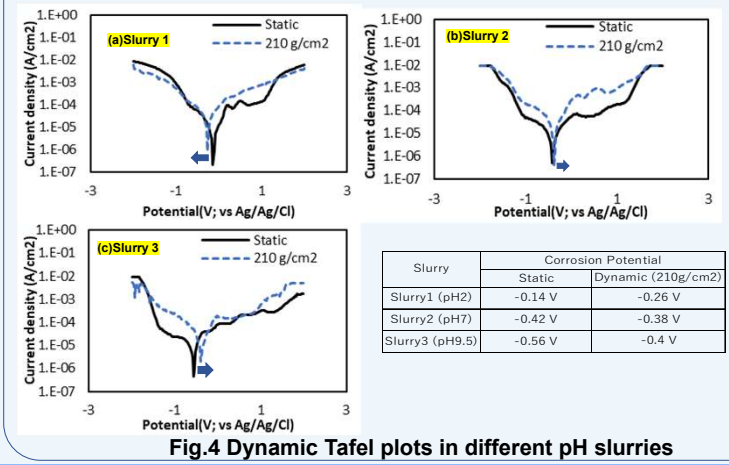
3. Experimental and Results

Tafel plot of Cu obtained under dynamic condition was compared with that obtained under static condition. In this evaluation, 2 cm x 3 cm sized Cu coupons were used. Slurries shown in Table 1 were used for this experiment.

Table 1 Slurry composition

Slurry No.	pH	Composition
1	2	Citric acid(6.1wt%) + BTA(0.24wt%)+ colloidal silica (Φ35nm: 1wt%)
2	7	Same as slurry 1(+ KOH as pH adjusting)
3	9.5	Same as slurry 1(+ KOH as pH adjusting)

Corrosion potential of Cu in slurry 1 is shifted to minus potential direction under the dynamic condition. It is thought that Cu surface in the acidic slurry is more easily corroded than static surface. On the contrary in slurry 3, corrosion potential under the dynamic condition is shifted to plus potential direction and saturated current region of anodic potential still remained.



Slurry	Corrosion Potential	
	Static	Dynamic (210g/cm2)
Slurry1 (pH2)	-0.14 V	-0.26 V
Slurry2 (pH7)	-0.42 V	-0.38 V
Slurry3 (pH9.5)	-0.56 V	-0.4 V

Fig.4 Dynamic Tafel plots in different pH slurries

Corrosion potential of Cu in the slurry shifted to minus direction of potential as higher down force is applied. Where, potential value at 350 g/cm^2 is same as that at 210 g/cm^2, which is thought to be due to the saturation of removal rate of Cu with slurry 1 over the 210 g/cm^2 down force. Saturated tendency in anodic current is also obviously disappeared and comes higher as higher down force is applied. Where, saturation region slightly remines in 70 g/cm^2 polishing while that is not observed in 210 g/cm^2. It suggested that the threshold downforce to remove passivation layer completely in slurry 1 is during 70 – 210 g/cm^2.

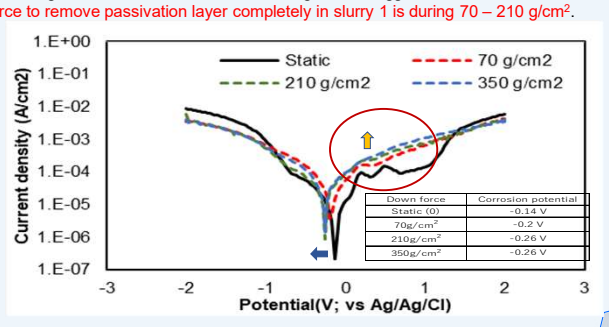


Fig.5 Dynamic Tafel plots at different pH slurries

4. Conclusion

Dynamic electrochemical measurement system (d-EC) was developed and applied for a fundamental Cu CMP study.

- Corrosion potential of Cu obtained under dynamic condition was shifted toward minus potential compared to the static condition in acidic slurry while the corrosion potential shifted toward plus potential in neutral and alkaline slurry.
- Current density of Cu in Tafel plot under dynamic (CMP) condition with acidic slurry comes higher as polishing pressure comes high while the tendency was not observed with alkaline slurry.
- These results suggest that Cu passivation layer formed in acidic slurry are removed easier than that in an alkaline slurry.