

光学顕微鏡その場観察による金属細線チャネルでのエレクトロマイグレーションの検討

Study on Electromigration Process of μm -Scale Metal Wires

Using In-Situ Optical Microscope Observation

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Introduction

[1] K. Takahashi et al., J. Vac. Sci. Technol. B 27 (2009) 805. [3] D. R. Strachan et al., Phys. Rev. Lett. 100 (2009) 056805.
[2] T. Taychatanapat et al., Nano Lett. 7 (2007) 652-656.

Electromigration (EM) has been used as a fabrication technique for closely spaced electrodes.

Feedback-Controlled Electromigration (FCE)^[1]

In-Situ Observations of EM Process Using Scanning Electron Microscope^[2] and Transmission Electron Microscope^[3]

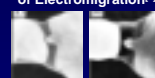
High Voltage, High Vacuum Environment, Complicated Procedure and Expensive Facility

In-Situ Optical Microscope (OM) Observations during Electromigration of μm -Scale Metal Wires in Air

This technique is simple and can easily investigate the electromigration process.

Investigation of Formation Process of Gaps in Voltage-Ramped and Feedback-Controlled Electromigration

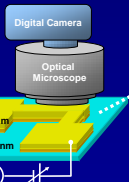
In-Situ SEM Observation of Electromigration^[2]



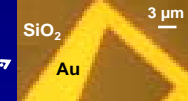
In-Situ Observation of Gap Formation by Voltage-Ramped Electromigration

Observation System

- In Air
- Total Magnification 6000 \times
- Wire Width 3 ~ 4 μm

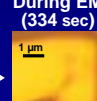
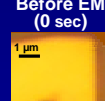


Optical Microscope (OM)



- Wires Width approximately 3 μm
- Wires Length 20 ~ 30 μm

EM Process^[4]

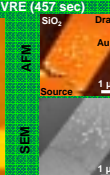
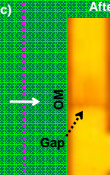
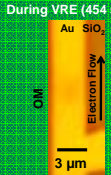
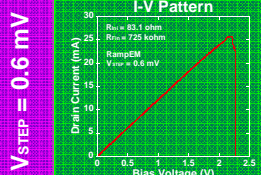


- In-Situ Real Time Observation of Formation Process of Gaps Using This System
- Good Agreement between OM, AFM and SEM Images of the Gap

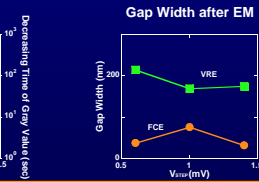
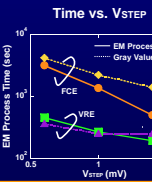
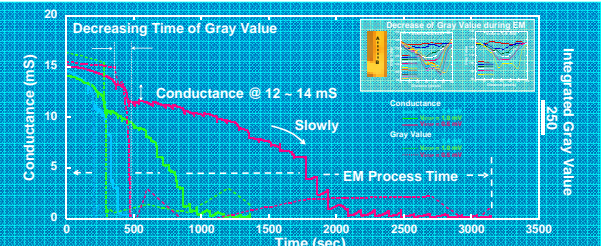
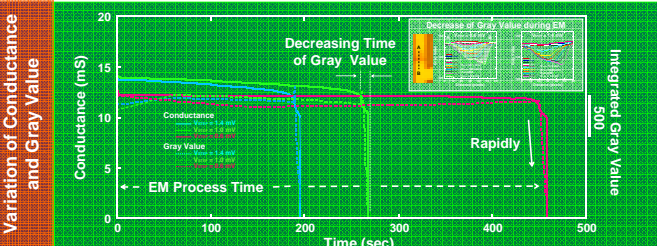
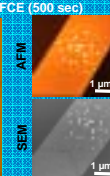
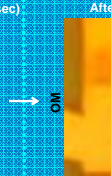
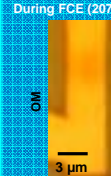
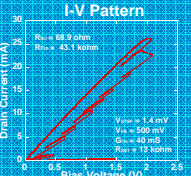
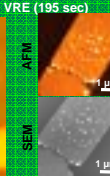
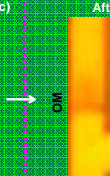
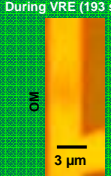
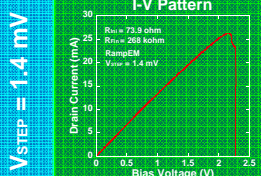
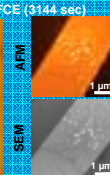
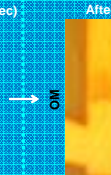
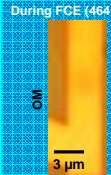
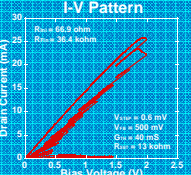
[4] 桑原 第55回応用物理学会学術大会講演要旨集1p-ZQ-6(2009).

Investigation of Electromigration Process Using In-Situ Optical Microscope Observation

Voltage-Ramped Electromigration (VRE)



Feedback-Controlled Electromigration (FCE)



Process Time:
VRE (195 ~ 458 sec) < FCE (501 ~ 3144 sec)
Longer Process Time Obtained by FCE

Conductance variation from 12 to 14 mS corresponds to the range of 140 in gray value.

Easy Observation of Physical Phenomena during FCE

Investigation of Conductance during FCE Using Gray Value Estimated by OM Images

Conclusions

In-Situ Optical Microscope Observations for Electromigration Process in μm -Scale Metal Wires

Investigation of Gap Formation Process during electromigration (Voltage Ramped and Feedback-Controlled)

Comparison of Variation Time of Conductance with that of Gray Value during Electromigration

Conductance variation from 12 to 14 mS corresponds to the range of 140 in gray value (Feedback-Controlled).

These results imply that in-situ optical microscopy allow to easily investigate EM in ambient air.