

Investigation of Electromigration in Micrometer-Scale Metal Wires by In-Situ Optical Microscopy

Yosuke Kuwabara, Shinya Nishimura, Rizal Zaharuddin, and Jun-ichi Shirakashi

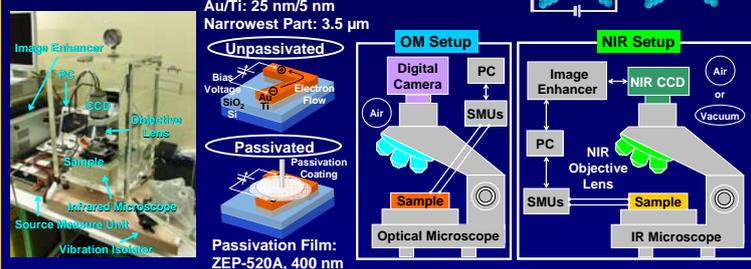
Department of Electrical and Electronic Engineering
Tokyo University of Agriculture and Technology



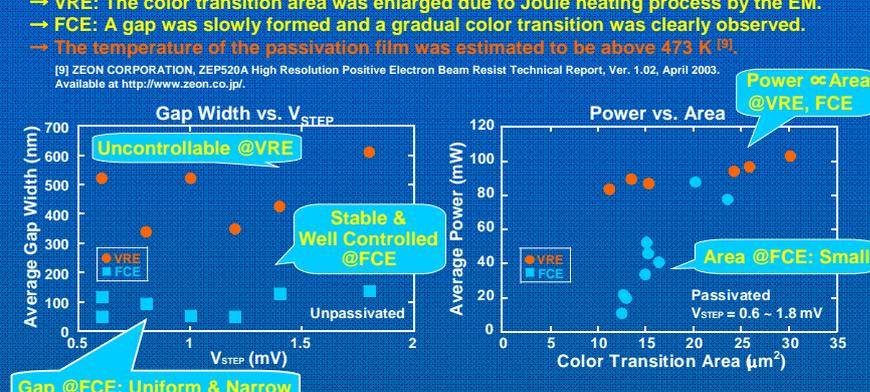
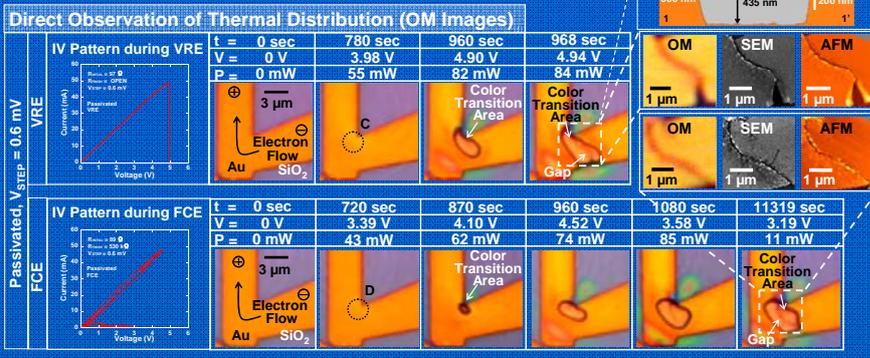
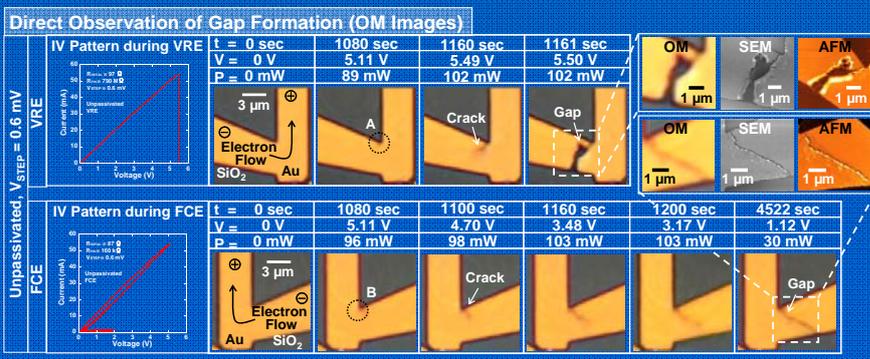
1. Introduction

- ◆ Fabrication Technique for Closely Spaced Electrodes by **Electromigration (EM)** [1, 2]
 - Joule heating and local temperature play a key role for the evolution of EM [3].
 - ◆ **EM-Induced Gap Formation** in Au Wires [4, 5]
 - Scanning Electron Microscopy (SEM) & Transmission Electron Microscopy (TEM)
 - High Voltages and/or High Vacuum Environments
 - ◆ **Heating in Al [6, 7] and Pt [8] Wires before and during EM**
 - In-Situ Temperature Measurements Using Thermal Emission Microscopy
 - Complicated Experimental Procedures and/or Expensive Facilities
- [1] H. Park et al., Appl. Phys. Lett., vol. 75, pp. 301-303, 1999. [2] D. R. Strachan et al., Appl. Phys. Lett., vol. 86, pp. 043109, 2005. [3] T. Taychatanapat et al., Nano Lett., vol. 7, pp. 652-656, 2007. [4] D. R. Strachan et al., Phys. Rev. Lett., vol. 100, pp. 056805, 2008. [5] M. L. Trouwborst et al., J. Appl. Phys., vol. 99, pp. 114316, 2006. [6] S. Kondo et al., J. Appl. Phys., vol. 79, pp. 736-741, 1996. [7] S. Kondo et al., Appl. Phys. Lett., vol. 67, pp. 1686-1688, 1995. [8] D. R. Ward et al., Appl. Phys. Lett., vol. 53, pp. 213108, 2008.
- This Study: Investigation of Electromigration by In-Situ Optical Microscopy**

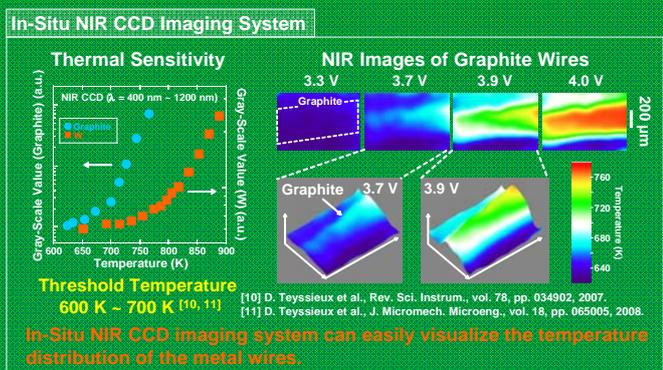
2. Experimental Setup



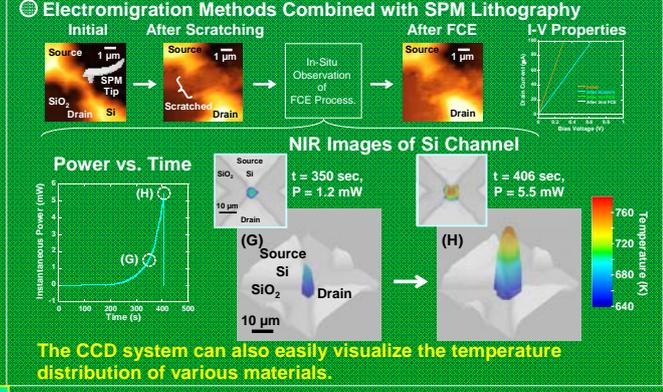
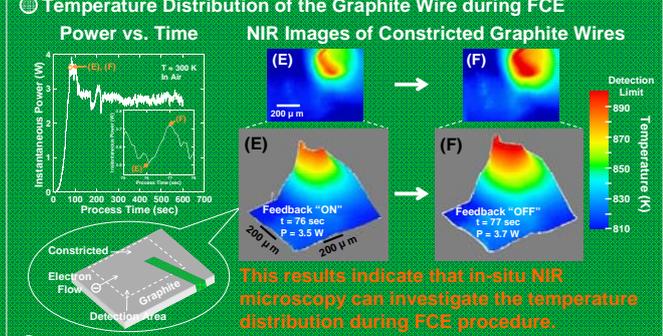
3. In-Situ Optical Microscopy (OM) of Electromigration



4. In-Situ Near-Infrared (NIR) Microscopy



FCE Procedures in Graphite Wire and Si Channel



5. Conclusions

It is suggested that the simple NIR CCD imaging system can easily obtain NIR images during EM of μm-Scale metal wires.

- ◆ Gap Formation and Thermal Distribution during EM in μm-Scale Metal Wires Investigated by In-Situ Optical Microscopy
 - A gap was formed **rapidly** in VRE and **slowly** in FCE processes.
 - The color variation of the passivation film was **clearly visualized** around the gap and was **gradually caused** in the FCE procedure.
 - ◆ A Hand-Made, In-Situ NIR CCD Imaging System
 - The threshold temperature for detection in the system is approximately 700 K. ⇒ Simple NIR CCD imaging system can easily obtain NIR images during EM.
- In-situ optical microscopy can simply and easily investigate EM process of various materials in ambient air.**