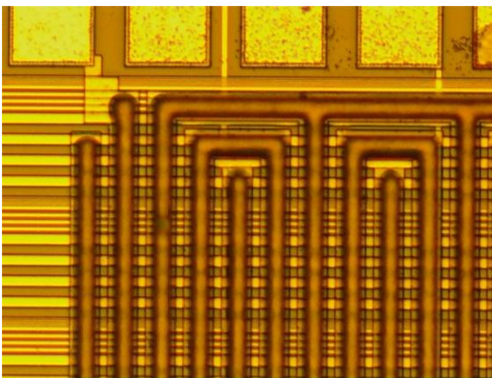
Reactive Ion Etching (RIE)

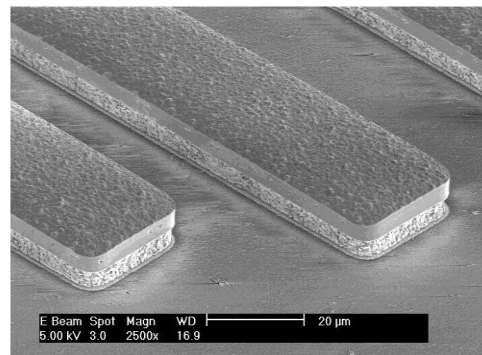
We are interested in understanding the plasma etching mechanism, which includes plasma phase chemistry, plasma-surface reactions, and surface reactions. We specialize in studying etch processes of non-conventional thin-film materials such as copper, indium tin oxide, metal oxides, a-Si:H, SiN_x, and $SiGe_x$, for future generations of VLSI, TFT, and other microelectronics or opto-electronics. High temperature RIE is a powerful method that has the advantages of a simple reactor design and being easy to transfer to accommodate large substrates (e.g. 12" for VLSI and 1m x 1m for TFT LCDs). Some examples of recent results are shown as follows. For more detailed information, please see the Publications List.

Plasma-Based Copper Dry Etching Process

- the first world record of room temperature plasma etch process

- Applications in commercial IC fabrication – BiCMOS chips



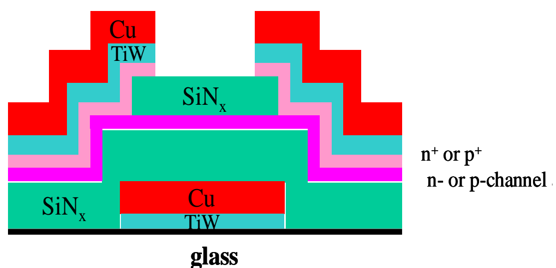


Kuo, Proc. ICRP-6/Spp-23 2006

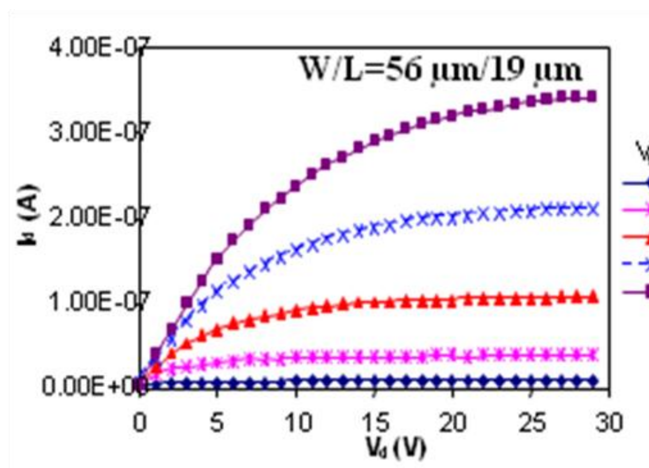
- Applications in commercial TFT LCD fabrication – LG 15.0-inch (XGA) LCD

Yang et. al, TFT 9 2008

- Applications in complete Cu source, drain, and gate electrodes in a-Si:H TFT



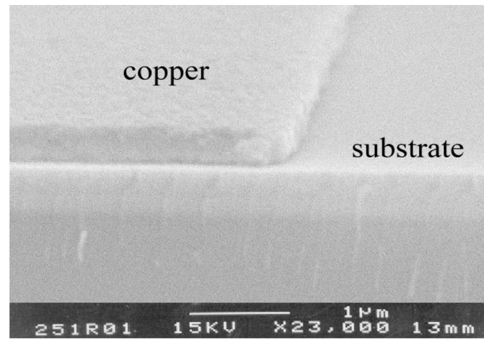
Liu & Kuo, ECS Plasma XV proc. 2003.



Kuo, et al, JKPS, 2005

- Room Temperature Process

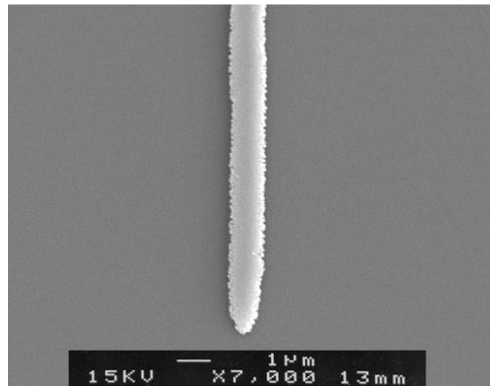
Vertical Profile



Y. Kuo and S. Lee. Appl. Phys. Lett. 78(7), 1002-1004, 2001.

S. Lee and Y. Kuo. J. Electrochemical Society. 148(9), G524-529, 2001.

0.8μ Line

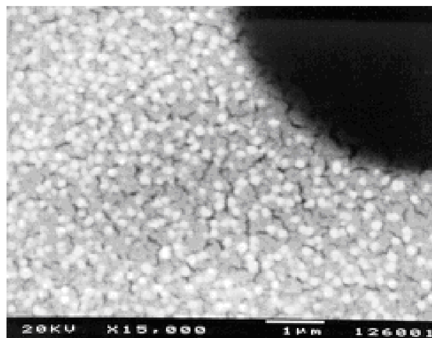


A 0.8 micrometer Cu line etched by HCl/Ar plasma

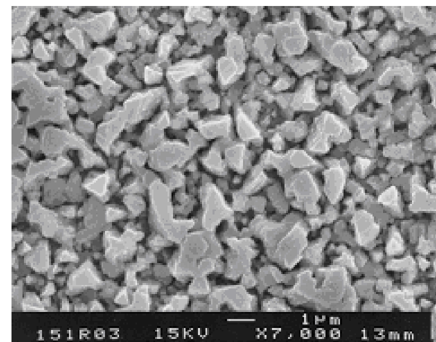
Y. Kuo, et al. Proc. ISSP 2003, p. 305-308. and Vac. 2004

- No Plasma vs. Plasma

HCl Exposed Cu – no plasma



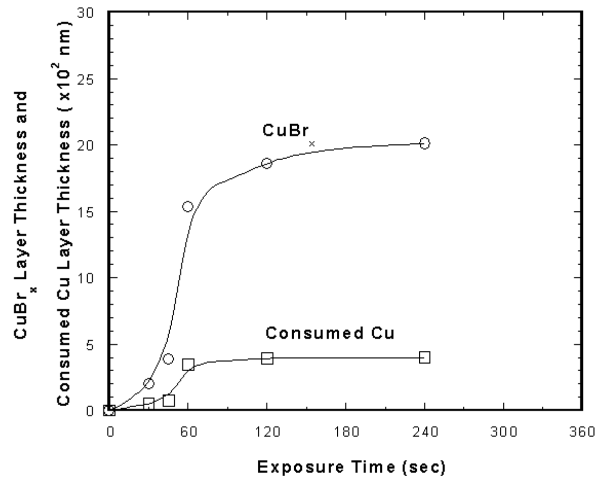
HCl Plasma Exposed Cu



S. Lee and Y. Kuo, JJAP 41, 1(12), 2003.

- Process Parameters: exposure time

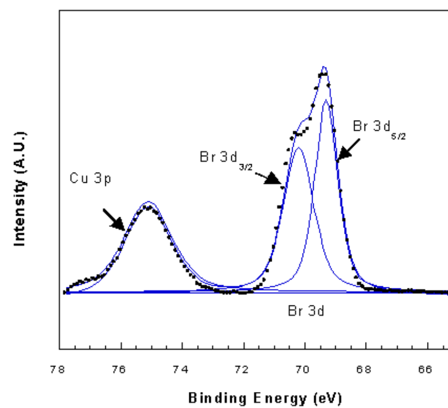
HCl Exposed Cu



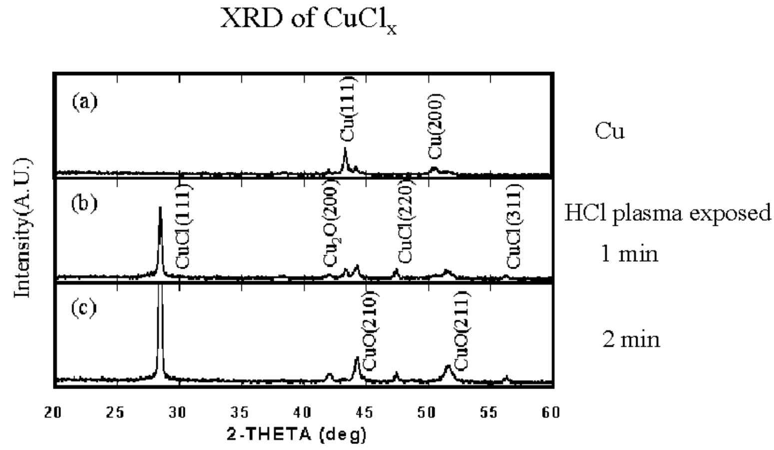
S. Lee and Y. Kuo, Thin Solid Films, 2003.

- Structures of plasma-Cu reaction products

$CuBr_x$ from HBr Plasma Exposure

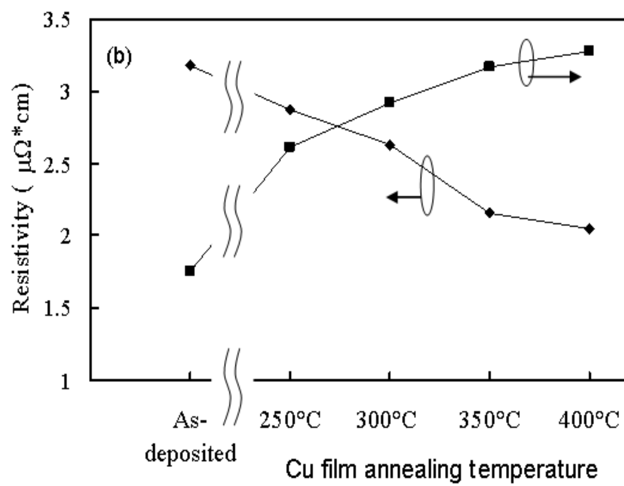


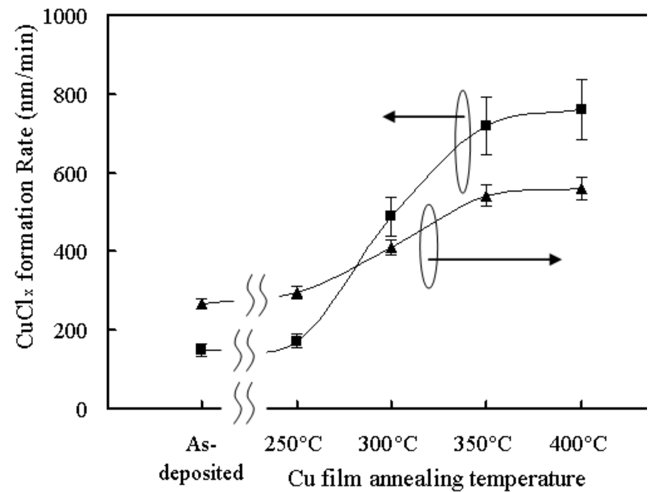
S. Lee and Y. Kuo, Thin Solid Films, 2003.



S. Lee and Y. Kuo, JJAP 41, 1(12), 2002.

- Grain Size Effects



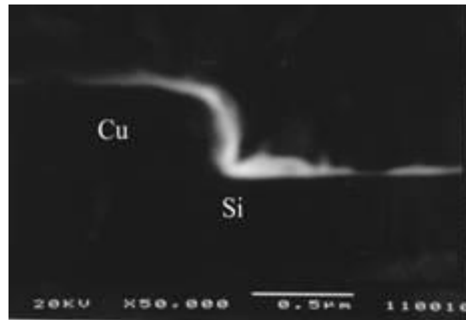


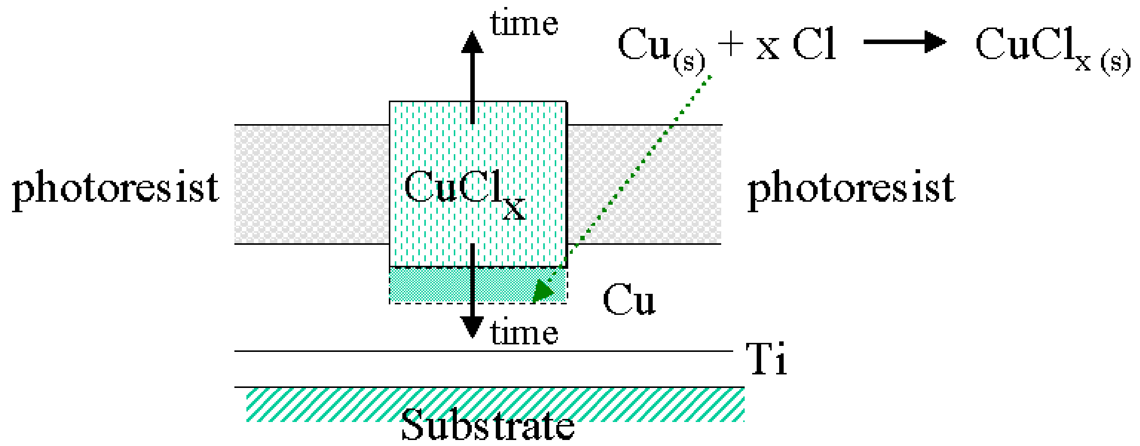
Cu film grain size and resistivity change with temperature

$CuCl_x$ formation and Cu conversion rates vs. temperature

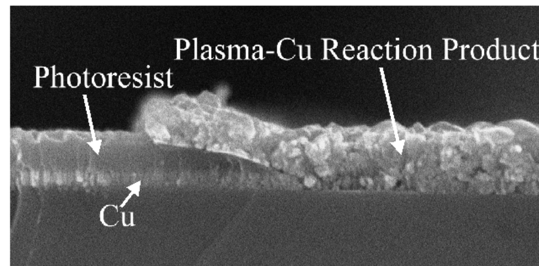
G. Liu, Y. Kuo, et al., JES 155 H432 (2008).

- Reaction Mechanisms

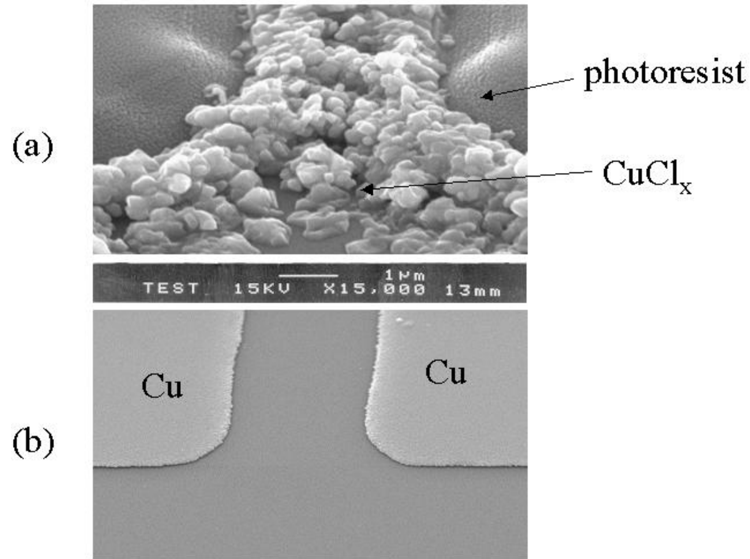




Y. Kuo and S. Lee, ECS Proc. 99-30, 328, 1999.

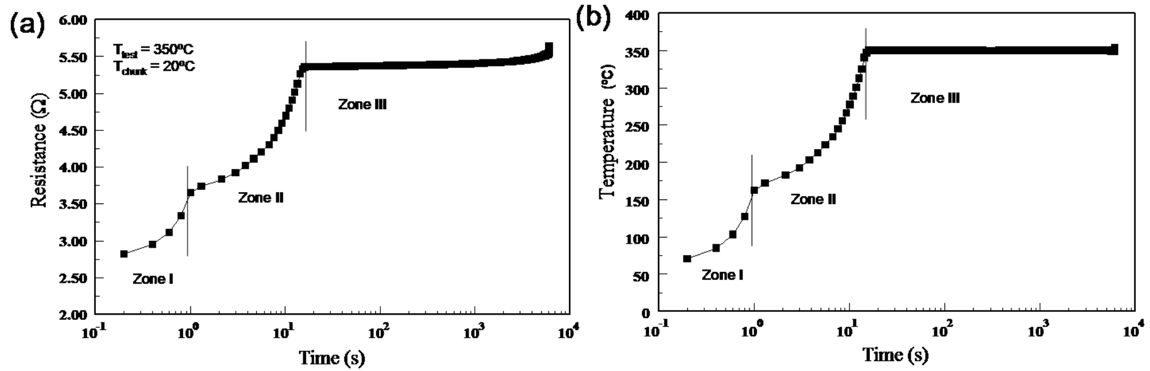


Y. Kuo & S. Lee, Jpn. J. Appl. Phys. 39, 2(3A/B), L801, 2000.

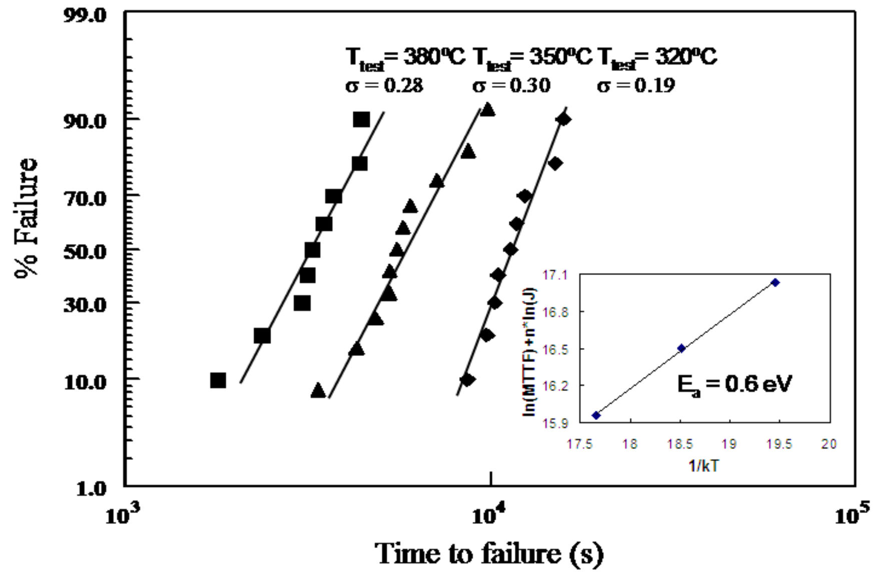


Y. Kuo & S. Lee, APL 78(7), 1002, 2001.

- Reliability of Etched Cu Lines – Electronmigration tests

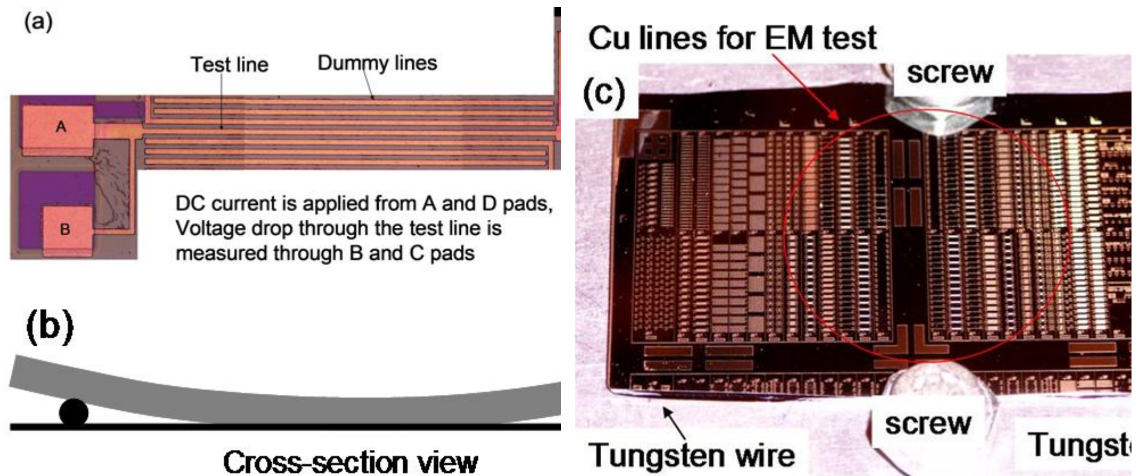


Isothermal EM test (a) resistance and (b) temperature vs. time during.

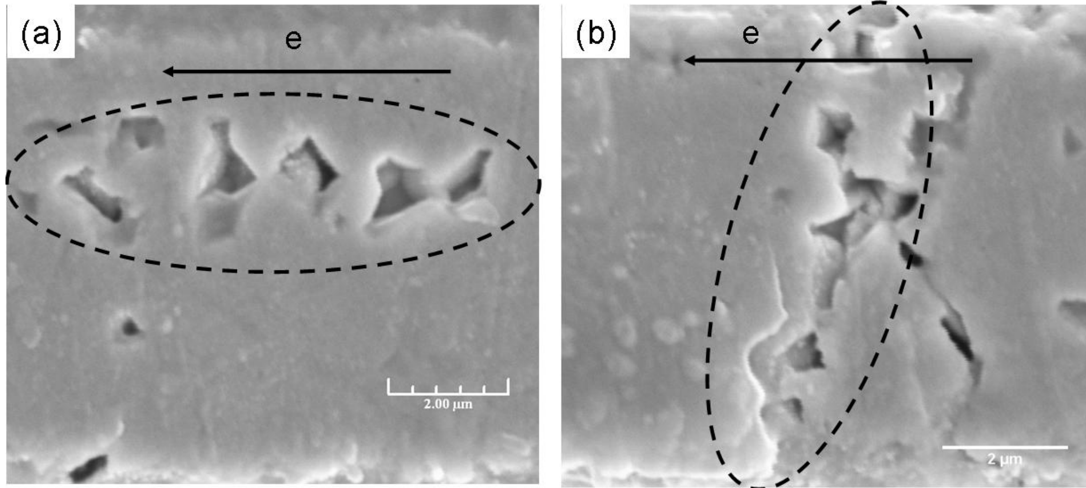


Cumulative failure distribution of flat Cu lines

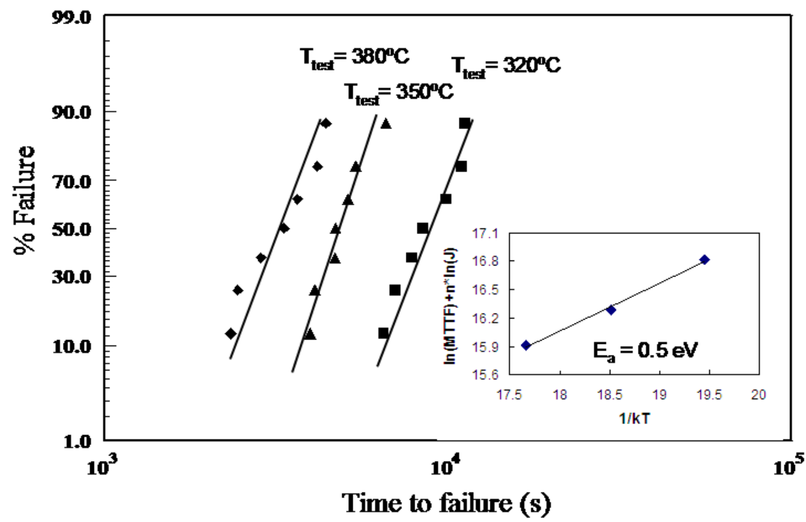
- Reliability of Flexible Electronics Application of Etched Cu Lines



(a) Cu line for EM test. (b) 3-point bending setup. (c) Bent Cu line sample plate.



Void distributions in (a) flat line and (b) bent line of EM at 350°C.



Cumulative failure distribution of bent Cu lines