

Evaluation of 2D materials as potential barrier layers for the future metal interconnect technology

Y. W. Lum¹, S. El Kazzi^{1,2*}, S. Pasko³, O. Whear³, S. Vajandar¹, T. Osipowicz¹, and U. Mirsaidov^{1,2}

¹Department of Physics, National University of Singapore, 117551 Singapore

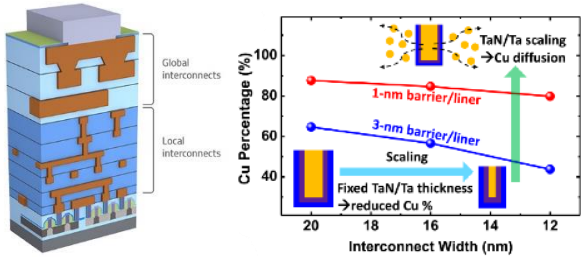
²NUS Advanced Materials Corporate Lab, 5 Engineering Drive 1, Blk E6 #05-09, 117608 Singapore

³AIXTRON SE, Dornkaulstr. 2, Herzogenrath, 52134 Germany

*Corresponding author: dbssali@nus.edu.sg



Introduction



- In the current IC chips, Cu is the main core metal used in the interconnect part
- To prevent Cu diffusion, a barrier/liner system is usually inserted at the metal/dielectric interface [1]
- **For future scaled trenches, barrier/liner system needs to be reduced to less than 1.5 nm [2]**

Objective

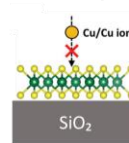
Use of 2D (Two-dimensional) family materials as potential barrier/liner candidates for the future metal interconnects.

Why?

- Atomically thin by nature
- Interatomic distance blocks efficiently Cu
- Passivated surfaces → Van der Waals interaction with Cu leading to lower its resistivity[3]

In this work: a metrology campaign has been developed to investigate 4 main criteria of a MOCVD WS₂ barrier

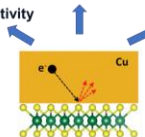
1) Blocking efficiency



2) Metal Resistivity

3) Wettability

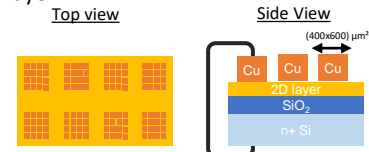
4) Adhesion



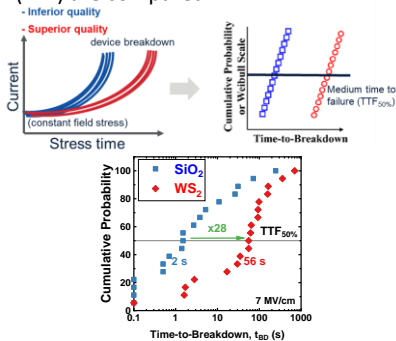
Methods and Results

(1) Blocking Efficiency

MOSCAP devices were fabricated to study the blocking efficiency of the 2D layer.



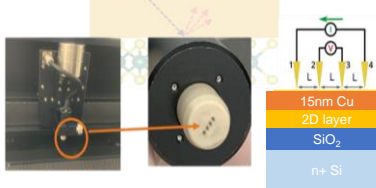
Time-dependent dielectric breakdown (TDDB) of different devices are measured and their Time-to-failure (TTF) are compared.



x28 TTF improvement with 2D-WS₂

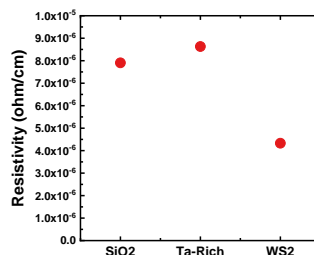
(2) Metal Resistivity

Four-point Probe Measurement



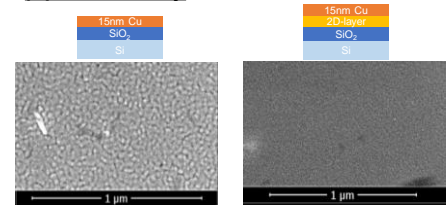
The metal resistivity can be deduced using the following equation:

$$\rho = \frac{R_{sheet}}{thickness}$$



Cu Resistivity is decreased with 2D-WS₂

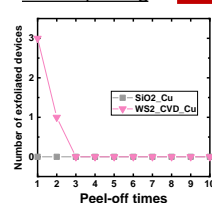
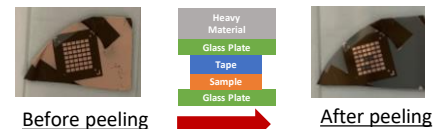
(3) Wettability



A smoother surface is obtained when Cu is deposited on WS₂/SiO₂

(4) Adhesion:

A standard tape peeling test was applied on 100nm Cu trenches



Only 4 devices were peeled off after 10 trials → **good Cu adhesion with the 2D surface**

Nanoindentation experiment is on-going to compare the result

Summary and outlook

- A first test campaign was developed to evaluate the barrier/liner properties of 2D materials
- WS₂ grown by MOCVD seems to show a promising barrier and liner for the Cu metal
- Different 2D layers will be tested in this process vehicle to choose the best candidate for future metal interconnect

[1] C. Witt, K. B. Yeap, A. Leśniewska, D. Wan, N. Jordan, I. Ciofi, C. Wu, and Z. Tókei, in IEEE International Interconnect Technology Conference (IEEE, 2018), pp. 54–56.

[2] J. Koike et al. 2006 International Interconnect Technology Conference, Burlingame, CA, USA, New York: IEEE (2006, June 5–7)

[3] C-L Lo et al., J. Appl. Phys. 128, 080903 (2020)

