INVESTIGATION OF CARBON NANOTUBE AS THE FILLING MATERIAL FOR INTEGRATED CIRCUIT CONTACTS AND VIAS

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1 Introduction

Based on the ITRS (International Technology Roadmap), the integrated circuit feature size has been shrinking rapidly.

The contact and via are usually the smallest and most abundant features in an integrated circuit.

The performance as well as the yield of the integrated circuit depends heavily on the robustness of the contact and via technology.

CNT can potentially provide a very small yet highly conductive and reliable contact/via filler for integrated circuits.

The objective of this project is to investigate the feasibility of using CNT for integrated circuit contact/via filler.

2 Fabrication

- A method to integrate the Cu/CNT composite as via filling material was developed.
- This integration scheme is compatible with current Cu interconnect technology.

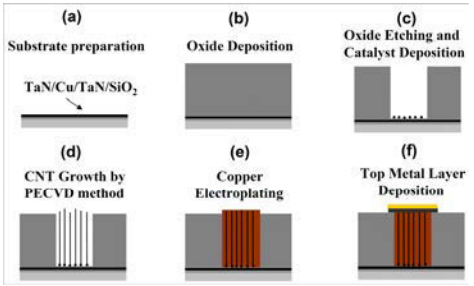

***Figure 1**: Schematic of the process flow to fabricate Cu/CNT composite vias.*

3 Characterization

- CNT vias
  - Via sizes varing from 1μm down to 100nm

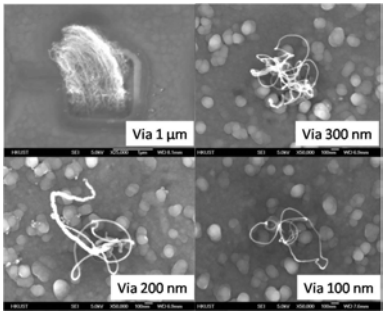

***Figure 2:** MWCNT grown through vias of different dimensions.*

  - The smallest via in our experiments

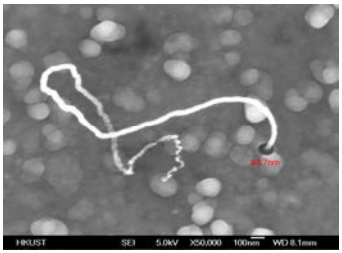

***Figure 3:** A single MWCNT grown through a via with diameter 93.7nm.*

- Cu/CNT composite via
  - The porosity in the CNT via is decreased by Cu fillings, forming a more compact conductive channel.

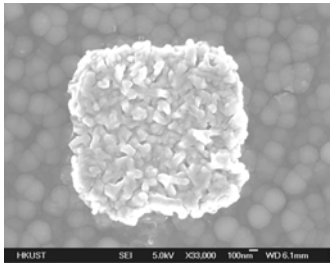

***Figure 4:** An SEM image of a Cu/CNT composite via.*

4 Results & Discussion

- I-V measurements using two-via-chain test structure

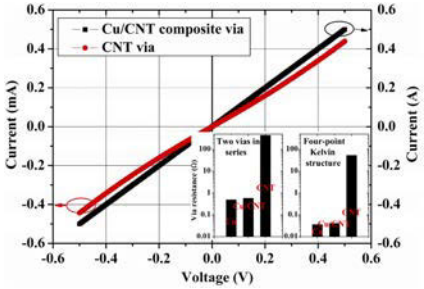

***Figure 5**: Current-voltage curves of CNT and Cu/CNT composite vias. Inset: average via resistance of Cu, CNT and Cu/CNT composite via measured with two-point and four-point structure.*

- Resistance measurement using Kelvin test structure

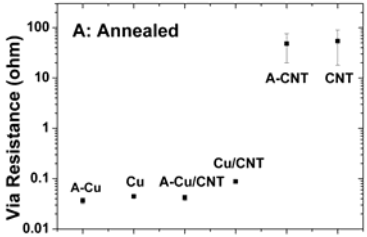

***Figure 6**: Statistical distribution of the resistances of the Cu via and Cu/CNT composite via at room temperature. The data are for 1.2 μm by 1.2 μm via holes.*

***Table 1**: Comparison of electrical resistivity of the vias filled with CNT, Cu and Cu/composite measured at room temperature.*

Via samples	Annealing	Effective resistivity	Standard deviation
Cu/TaN	NO	4.43 μΩ•cm	11.3%
Cu/TaN	YES	3.68 μΩ•cm	4.8%
Cu(CNT)/TaN	NO	8.79 μΩ•cm	12.6%
Cu(CNT)/TaN	YES	4.49 μΩ•cm	7.3%
Ideal CNT	___	10^{-1} μΩ•cm	REF [2]

- Conclusions

The different types of via were fabricated, and their physical and electrical properties were investigated. We found that the copper filled CNT vias have superior resistance to electromigration over industry standard copper vias. One CNT per via demonstrated in this study may have great potential for future application.

5 Acknowledgements

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