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Carbon nanotube-based sensor Device compatible with the CMOS process

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1. Introduction

Carbon nanotube (CNT) electronic devices are very promising for replacing state-of-the-art electronic devices on silicon-based technologies and can open up the possibility to be the next generation electronic devices [1]. The production temperature of the carbon nanotube is higher than the limitation of the CMOS. Almost the metal used in CMOS is Al-Si-Cu alloy, which make the sustainable temperature of CMOS structures be in the range of 400-500°C [2-3]. Therefore, we offer a new fabrication method of CNTs-based sensor compatible with the Taiwan Silicon Manufacturing Company (TSMC) CMOS process at low temperature.

2. Experimental

After TSMC 0.35μm CMOS process the cross sectional profile of the chip ,which was coated a protection photoresist is shown as Fig. 4(a). The upper metal were made by an e-beam evaporating 50 nm SiO_2 on the chip surface as shown in Fig. 4(b). Then we removed the photoresist which has SiO_2 on the surface as shown in Fig. 4(c). We used conventional photolithographic method to defined the shape of interdigital electrode (IDE) on the chips surface as shown in Fig. 4(d). Then IDE fingers were made by an e-beam evaporating 100 nm Al on the chip surface as shown in Fig. 4(e). The fabrication of the IDE was carried out by lift-off process with a finger width of 10 μm and a gap size of 10 μm as shown in Fig. 3 and Fig. 4(f).

We were coated a protection photoresist is shown as Fig. 4(g).The CNTs powder be used in this paper, which has ~ 95% purity (prepared by an arc-discharge process). A stable suspension of CNTs in NMP was prepared by sonicating CNTs material in N-di-methylformamide (TEDIA) in a bath sonicator at a concentration of ~0.1 mg/ml for 35 h. The surface of chips were first cleaned with ethanol and acetone and blown dry with nitrogen. A self-assembled monolayer(SAM) with –NH2 termination [4] was prepared by soaking the oxidized Si chips in 1 mM solution of 3-aminopropyltriethoxysilane (Sigma-Aldrich) with acetone for 30 min [5]. Then the chips were rinsed in ethanol and acetone again and blown dry with nitrogen. After the treatment, chips surfaces became hydrophilic due to complete coverage with an APTS monolayer. CNTs were deposited on the functionalized surfaces by soaking the APTS-Si chips in nanotube solution for 12 h as shown in Fig. 1. The chips were rinsed by methanol immediately after immersing the CNTs/NMP solution. Afterwards, the chips were blown dry with nitrogen as shown in Fig. 4(h). Fig. 2 showed the SEM image of MWCNTs adhesion on the APTS monolayer. Then we removed the photoresist which has CNTs on the surface as shown in Fig. 4(i). The remaining processes are shown in Fig. 4.

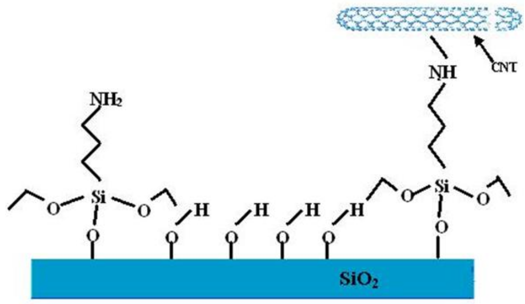


Figure 1. Schematic diagram of deposition of CNTs on the amino silanised SiO_2 surface.

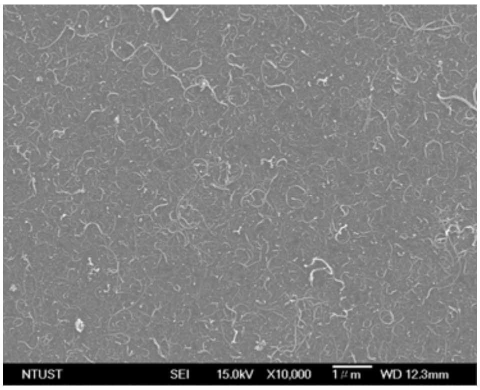


Figure 2. The SEM image of MWCNTs adhesion on the APTS monolayer.

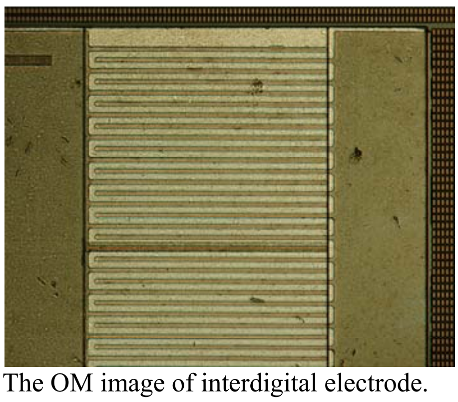


Figure 3. The OM image of interdigital electrode.

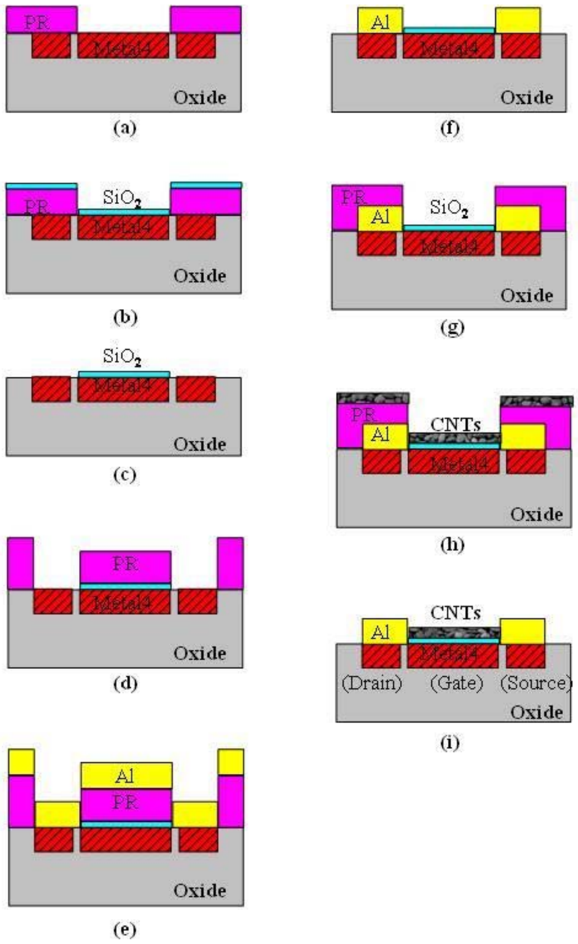
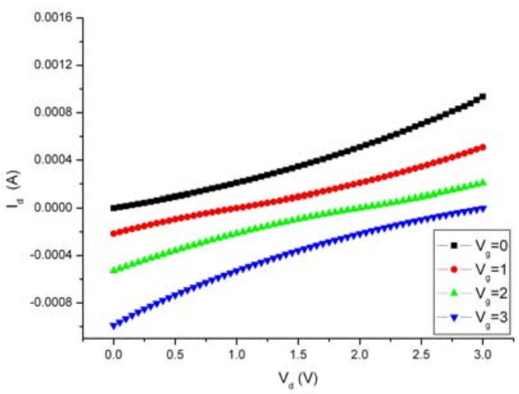


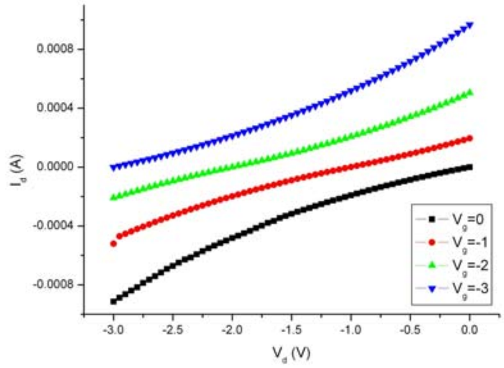
Figure 4. fabrication process.

3. Results and Discussion

The sensor device apply a bias voltage from -3V to +3V on the drain and source, and a varied voltage from -3V to +3V on the gate, measure the output with different voltage supply by using Keithley Parameter Analyzer (Keithley 4200) as shown in Fig. 5. Our results reveal a CNTs-based sensor device can be integrated into CMOS IC at low temperature.



(a)



(b)

Figure 5. (a)and(b) are apply a bias voltage from -3V to +3V on the drain and source, and a varied voltage from -3V to +3V on the gate, measure the output with different voltage supply.

4. Conclusions

We apply self-assembled monolayer of 3-aminopropyltriethoxysilane (APTS) to modify TSMC CMOS chip surfaces and increase adhesion between CNTs and chip surface. Furthermore, we also successfully fabricated the carbon nanotubes based sensor device by conventional photolithography process on CMOS chip surface at low temperature.

Acknowledgements

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