Abstract Nowadays research on single CNT based nanoelctronic device arises much interest among researchers, but in the fabrication of CNT based nanoelctronic device, one of the key technical problems is to realize precise assembly and electrical contact between CNT and microelectrode. For solving the problem, first AC dielectrophoresis (DEP) method is used to coarsely position batch of CNTs near the microelectrode, then AFM based robotic nanomanipulation method is used to precisely position, assembly and make electric contact of the selected CNT. MWCNT assembly and electric contact experiments verify the effectiveness of these two methods' integration.

Keywords- Precise assembly, electrical contact, MWCNT, AC DEP, Robotic nanomanipulation

I. INTRODUCTION

As carbon nanotube (CNT) has many unique properties, such as special strength properties [1][2], heat properties [3], especially it has special electrical properties to be conduct or semi-conduct with different diameter and helix angle [4~6], and also due to its nanometer size and one-dimension shape, it becomes a kind of promising material to substitute silicon material in fabricating micro/nano electronic device, and currently it is used to fabricate various kinds of nanoelctronic device such as CNT-based nano transistor [7][8], nano chemical gas sensor [9], etc.

However, it is one of the key technical problems to realize precise assembly and electrical contact between CNT and microelectrode in nanoelctronic device’s fabrication, and several methods were proposed for solving it. Dispersed CNTs solution is directly spread and deposited randomly on the surface of microelectrode and thus the assembly and electric contact is realized [10], obviously its success ratio is very low. Dispersed CNTs solution is deposited on substrate and CNTs are actuated to microelectrode only by AC dielectrophoresis (DEP) technology [11], for always batch of CNTs or even bundles are absorbed to the microelectrode, it is difficult to make assembly and electric contact of predefined single CNT. CNT is grown at the predefined position of two microelectrodes [12], but it is in itself very difficult to accurately position the catalyst and control the CNT growth process. Dispersed CNTs solution is firstly deposited on the substrate, and then focused ion beam (FIB) lithography technology is used to make microelectrode with CNT and thus electric contact is formed [13], although the electric contact is reliable, CNT is prone to be destroyed by high energy FIB. And in these methods described above, there also exists a common shortcomings, that is, the position of predefined CNT cannot be precisely controlled and adjusted, which impeded the research of CNT based nanoelctronic device.

A new method to solve the problem is proposed with the integration of AC DEP method and AFM based robotic nanomanipulation method in this paper, that is, firstly batch of CNTs are coarsely actuated to microelectrode by AC DEP force, then the selected CNT is accurately pushed and assembled to the microelectrode, and additional CNTs are pushed outside the operation area with AFM probe. In this way, precise assembly and electrical contact of single CNT can be realized and experiments will be performed to verify the effectiveness of the method.

II. AFM BASED ROBOTIC NANOMANIPULATION SYSTEM

Recently AFM based nanomanipulation has been researched and various kinds of manipulation methods have been proposed [14~16]. However, these AFM based nanomanipulation methods can be cataloged into 'scan-design-manipulation-scan' mode, its main problem is the lack of real-time sensory feedback for the operator, the manipulation result can only be verified by another new scan for every manipulation step. Obviously, this manipulation mode is inefficient and inflexible, the probe is also prone to be broken without force information feedback, and all these shortcomings hamper the development and application of AFM based nanomanipulation.

For solving the problem, an AFM based robotic nanomanipulation system was built up as shown in Fig. 1 [17][18].

In the system, a sample-scanning AFM (model CSPM-2000wet, Ben Yuan Ltd., China) was used, where a scanner is equipped in the AFM head with XY scan range 50um and Z range 5um, and AFM nano-probe (model NSC15-F5, MickoMasch Inc., USA) with calibrated force
constant is also equipped in AFM head. A haptic device (Sensable Co., USA) is used for 3D nano forces feeling and motion commands input, that is, the forces are felt by operator from the haptic joystick and the scanner motion command produced by joystick is sent into the AFM control computer to control the scanner’s motion. The visual interface provides the operator with real-time visual feedback information of nano environment. The optical microscope and CCD camera help the operator to adjust the laser to focus on cantilever end and search for interesting area on sample.

During nanomanipulation, real-time 3D nano forces and visual information can be obtained, and several manipulation steps can be continued without break, and this kind of manipulation with various information feedback makes the nanomanipulation more efficient, intuitive and flexible [15].

III. MICROELECTRODE FABRICATION

The microelectrode is fabricated after the design of electrode material, geometric shape and size, and the fabrication process is shown in Fig. 2.

Firstly the doped silicon substrate is oxidated and the surface will be covered with a thin SiO2 film, then a thin photo resist film is deposited and photo-lithographed to get the microelectrode shape and size, then Cr/Au thin film is deposited and additional photo resist is removed by acetone, thus the microelectrode is obtained as shown in Fig. 3.
Several similar experiments are also done to verify the reliability and effectiveness of the two methods’ integration as shown in Fig. 7.

To verify whether the electrical contact is built or not, the I/V electric property of the MWCNT is measured before and after assembly by means of semi-conduct parameter analyzer (Agilent 4155C). As to the MWCNT shown in Fig. 6, the measured I/V property is shown in Fig. 8.

In Fig. 8(a), before assembly the measured current is about -4pA-4pA, and it is obviously caused by signal interrupt. After assembly the current flowing through the MWCNT reaches 650nA when the voltage applied on the microelectrode reaches 5V, obviously the electric contact is built up.

In addition, under the assistance of the AFM based nanomanipulation system, the assembled MWCNT can also be pushed off the microelectrode and other MWCNT can be pushed to the micro electrode, thus the micro electrode can be used to measure the electric property of different MWCNT and thus used to select the suitable MWCNT.

V. CONCLUSION

For realizing CNT’s accurate assembly and electric contact in the fabrication of CNT based nanoelectric device, first AC dielectrophoresis (DEP) method is used to coarsely position batch of CNTs near the microelectrode, then AFM based robotic nanomanipulation method is used to precisely position, assembly and make electric contact of the selected.
CNT. MWCNT assembly and electric properties measurement experiments verify the effectiveness of these two kinds of technology’s integration, and it provides an effective strategy for assembling and fabricating nano-Bradford devices based on various nanotubes, nanowires etc.

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REFERENCE


