Measurement of a gauge factor of a carbon fiber and its application to sensors

S.M. Cho [a], C.R. Han [a], J.K. Kim [b], Y.S. Choi [b], C.S. Park [b], J.S. Park [b], D.W. Lee [a]

[a] MEMS & Nanotechnology Laboratory, School of Mechanical Systems Engineering, Chonnam National University, Gwangju, 500-757, Korea

[b] Graduate School of Mechanical Engineering, Chonnam National University, Gwang-Ju, 500-757, Korea,

Phone: +82-62-530-1684. E-mail: mems@chonnam.ac.kr

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Since their discovery in 1991, carbon nanotubes (CNTs) have drawn the interest of a large number of researchers, because of their extraordinary electrical and mechanical properties. By using a carbon nanotube as the semiconducting channel in a field effect transistor (FET), very high mobilities have been achieved, comparable to or better than state-of-art silicon-based transistors. It is also applied for sensor applications thanks to an extremely high gauge factor[1]. However, the batch fabrication technique that is widely used in an integrated circuit industry can't be easily applied in sensor fabrications because CNTs are too small and not easy to control during a photolithography process.

In this paper we present a new piezoresistive sensing element made by a carbon fiber with 10 μm in diameter. The carbon fibers are also one of candidates for a number of electronics, chemical & mechanical structures and sensing applications. It provides some advantages in comparing with the CNTs-based processes. Dielectrophoresis has recently been demonstrated as a route towards the selective deposition of metallic carbon fibers[2] and is moreover a method for controlled assembly of the carbon fibers on microstructures that has the possibility to be scaled to wafer-level manufacturing[3-6]. Numerical calculations of carbon fibers subjected to dielectrophoresis, drag force and Brownian motion induced by application of an ac voltage to a set of microelectrodes, shown in Fig. 1. We calculate and evaluate the probability of capturing various types of carbon fibers, the time frame for the assembly and the efficiency of separation and deposition, for different experimental parameters. Hence we can easily handle the carbon fiber without special equipments during the microfabrication process. The gauge factor of the carbon fiber is measured using a microfabricated flow sensor as shown in Fig. 2. Figure 3 shows a flow chart for the flow sensor fabrication. Figure 4 shows an optical image of the fabricated flow sensor. The carbon fiber is exactly placed between two electrodes by employing the dielectrophoresis method, shown in Fig 5. A schematic diagram to measure the flow sensor properties is shown in Fig. 6. The details of the carbon fiber-based sensor will be presented at the MNE conference.

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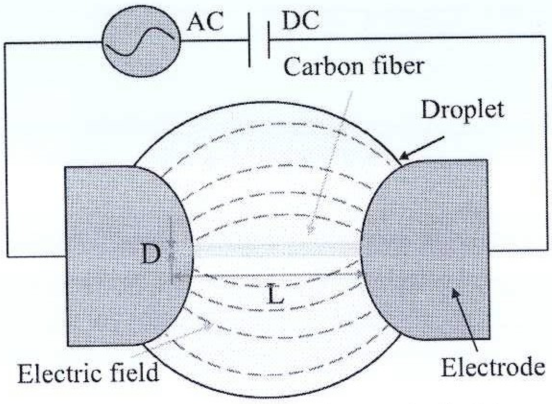


Figure 1. A selective deposition method of the carbon fiber.

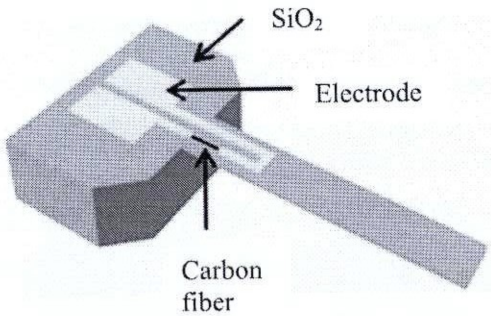


Figure 2. A cross sectional view of a cantilever type flow sensor

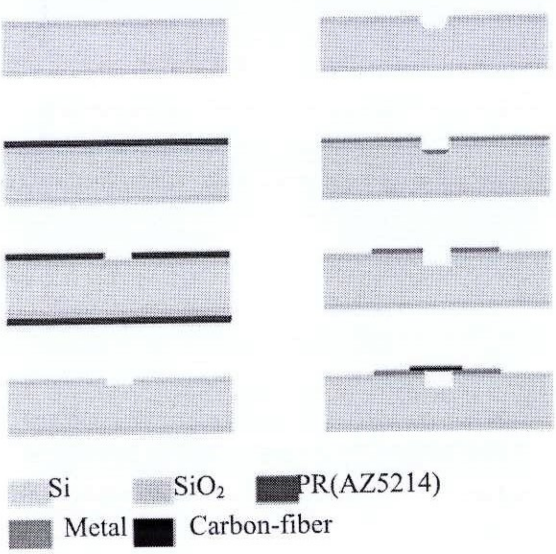


Figure 3. Process flow for the carbon fiber sensor fabrication.

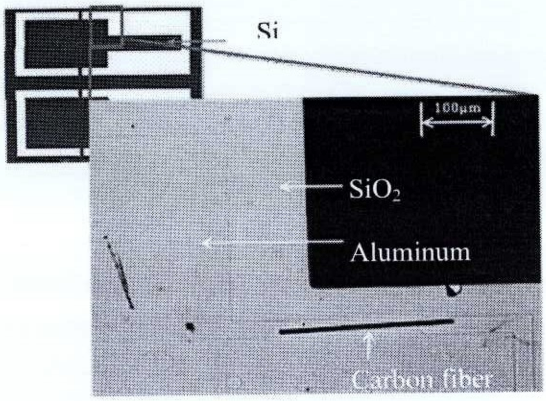
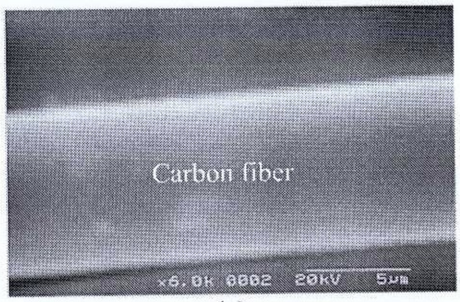
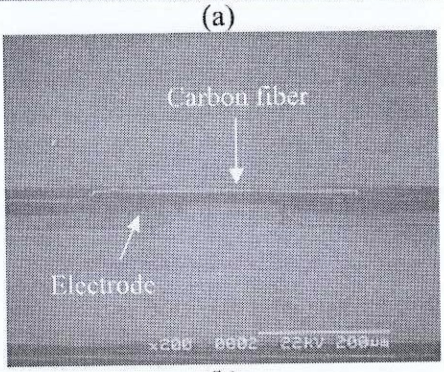


Figure 4. An optical image (X10) of the fabricated flow sensor.



(a)



(b)

Figure 5. (a) A SEM image of a carbon fiber (D=10 ㎛, L=280 ㎛), (b) A SEM image of cantilevered sensor using the carbon fiber as a sensing element.

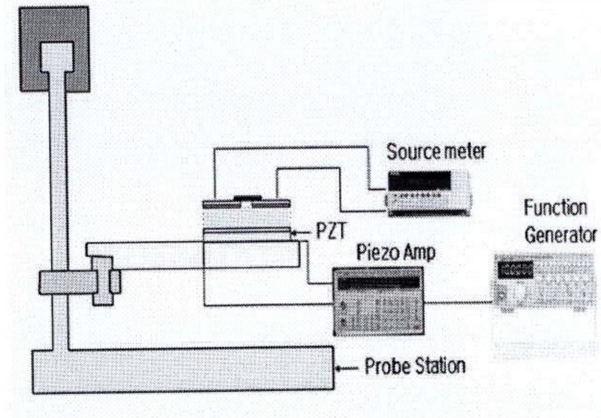


Figure 7. A schematic diagram of a measurement system