Selective synthesis of semiconductor-type single-walled carbon nanotubes

High selectivity (98 %) achieved

A novel method to synthesize the single-walled carbon nanotubes (SWNTs) of semiconductor-type is reported. Selective synthesis of semiconductor-SWNTs was realized by exposing iron catalysts to gas ambient containing small amount of H_2O just before SWNT growth. Raman spectra of the as-grown SWNT films have suggested the preferential growth of semiconducting SWNTs with small diameter of 0.8-1.2 nm range. Importantly, high selectivity was only achieved when the yield of CNTs was low, suggesting that selective growth can be achieved by adjusting the catalyst activity. High performance of a field effect transistor (FET) device was achieved by using an as-grown SWNT film as the channel of FET, where high on/off ratio (> 10,000) and mobility (c.a. 17 cm^2/Vs) at a relatively short channel length (5 μm) were indicated. These characteristics show that the approach of selective growth can greatly contribute to widespread electronics application, such as in flexible electronics devices.

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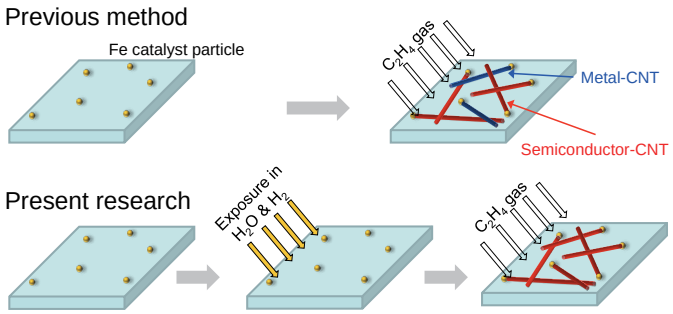

Schematically represented process of the selective growth of semiconductor-type SWNTs

200 mm wafer process for piezoelectric MEMS devices

Practical level piezoelectric constant (-d_{31}>105 pm/V) achieved by pulse poling

We have developed a 200 mm PZT wafer process for piezoelectric MEMS devices. Optimization of the PZT thin film deposition atmosphere and the thermal treatment condition has reduced the number of coarse particles formed on the surface of the PZT thin films, which leads to higher yield rate. We have fabricated piezoelectric MEMS devices from the 200 mm wafer. Pulse poling has resulted in a high piezoelectric constant d_{31} as high as -105 pm/V, where it takes less than 1 second for poling each of the piezoelectric MEMS devices.

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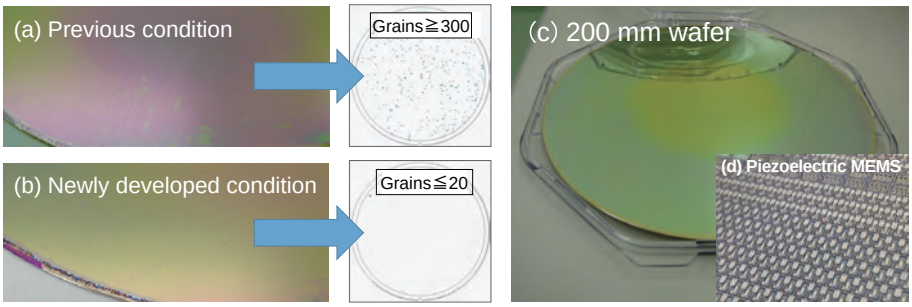

(a) Surface of a PZT thin film deposited under previous condition
(b) Surface of a PZT thin films deposited under the newly developed condition
(c,d) 200 mm wafer after PZT deposition and after piezoelectric MEMS fabrication process