Self-Aligned Carbon Nanotube Formation for Next Generation Transistor

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Beyond Si CMOS technology is the current challenging for next generation transistor. As demand for nano-scaled devices increase, the ability to manipulate the building blocks of electronic is essential. Catalytic-assisted CNTs are integrated into trenches and holes under CH_4/H_2 gases by microwave plasma chemical vapor deposition, the trench and hole are used to fabricate for gate electrodes and interconnections, respectively. Results indicate the orientation of grown CNTs is dominated by pattern geometry. The field emission results show that the CNTs exhibit robust electronic properties with emission densities of over $1mA/cm^2$ at 3.97 and 6.30 V/μm indicating the high electron emission efficiency as the CNT field effect transistor application. The growth models of Fe and $CoSi_2$ and application for nanoelectronics are purposed. Figure 1(a)-(c) depicts the CNTs that were selectively deposited vertically on patterned Fe trench arrays. When Fe catalysts are used with a SiO_2 interfacial layer, the catalyst is on the top of the tubes for a brief period, in which hydrogen reduction time is ≤ 5 min. A longer reduction time (10 min) forms chemical bonds between Fe and the SiO_2 film, causing the base growth of CNTs owing to strong Fe and SiO_2 adhesion. Using Fe catalysts with the SiO2 interfacial layer, cause Fe catalyst to be present on the top of the tubes for only a brief deposition time. A longer deposition time is suggested to cause bonding between Fe and the SiO2 film, resulting in the base growth of CNTs. According to the Fe-Si phase diagram, two phases, FeSi and FeSi2, are present at process temperature. The FeSi2 formed at long processing time is bound tightly to the substrate, resulting to base growth otherwise the top growth. For both top and base CNTs growth, the CNTs are constrained in the patterned Fe catalysts trench, indicating high deposition selectivity. The introduction of H_2 plasma pretreatment is considered to active catalyst. When SiO_2 is inserted, highly oriented CNTs are formed via catalyst films rather than catalytic particles. This process yields CNTs with a conformal diameter and length that is as determined from the TEM image shown in Fig. 1 (d-e). Fig, 2 presents the schematic diagram as interconnect of CNTs on Cu/CoSix process.This work studies the synthesis of selective deposition of CNTs on patterned trenches and holes using Fe and $CoSi_2$ catalysts. The results show that well-aligned CNTs are obtained using an Fe catalytic film and that the hydrogen pretreatment time dominates whether the catalytic film is located on the base or on the top. Wrapped CNTs are successfully formed in the $CoSi_2$ hole arrays. This study supports CNTs growth methods applied in the gate electrode and interconnection for next generation of nanaoelectronics.

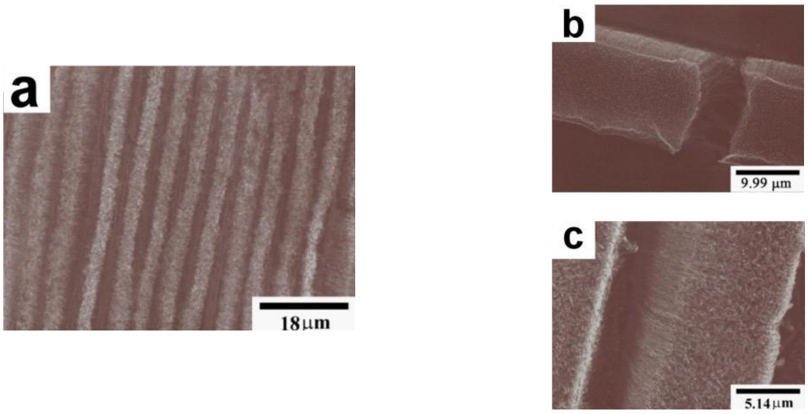

Fig. 1 Fe assisted CNTs deposition (a) trench arrays (b) and (c) high magnification, base and top growth for H_2 reduction time in 10 min and 5 min, respectively

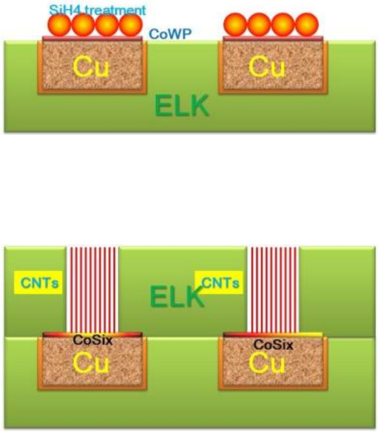

Fig. 2 Schematic diagram of Cu Damascene and CNTs integration

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