GROWTH OF CARBON NANOTUBES FROM NICKEL DOTS PREPARED BY ELECTRON-BEAM LITHOGRAPHY AND MAGNETRON SPUTTERING

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Ni dots of 150 nm diameter have been produced by electron beam lithography (EBL) equipment (RAITH Elphy Plus), magnetron sputtering and lift-off techniques. These are suitable for the growth of carbon nanotubes (CNTs) [1, 2] by plasma-enhanced chemical vapour deposition (PECVD). Dot size, Ni film thickness, distances between dots (below 1 μm) and electron exposure proximity effects, influence the diameter, internal structure, shape and growth rate of CNTs.

Application of carbon nanotubes in a myriad of nanoelectronic devices, scanning probes and field-emission sources, as well as integration of nanotubes with classic microelectronic technologies, require high-resolution control over the growth position of CNTs. Vertical alignment, achieved by PECVD, is important in applications to field emitters [3-5], which are currently being considered for use in flat-panel displays [6, 7]. Moreover, freestanding CNTs, aligned in such way, were proposed as nanoelectrodes for sensitive DNA detection, and for use in biosensors [8, 9]. In particular, vertical alignment is essential to achieving a high geometrical enhancement factor in field emitters.

Our results indicate that carbon nanotubes are multiwalled (MWCNT) and that their diameters are similar to those of the Ni dots. Figure 1 shows the distribution of CNTs grown by PECVD at 800ºC on Ni nanoparticles (in the frame zone) and on Ni dots (in the internal zone). The Ni nanoparticles in the frame were formed by annealing the Ni film, which was grown on c-Si wafer by magnetron sputtering, at 800ºC under vacuum (with a residual H_2 atmosphere to prevent oxidation). Ni nanoparticles with a diameter of about 100 nm were located in the frame zone, whereas Ni dots processed by EBL and lift-off, which showed constant size (100nm) and shape (circles), were located, forming a matrix, in the central zone (Figure 2).

In order to study the effects of electron beam dose gradation on the creation of Ni dots and growth of CNTs, we constructed a Ni frame surrounding a matrix of dots, so that the proximity effect would promote such gradation. Only one carbon nanotube grew from each dot, and a dependence of CNT height on the amount of Ni in each dot was observed (Figures 1 and 2).

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Figures:

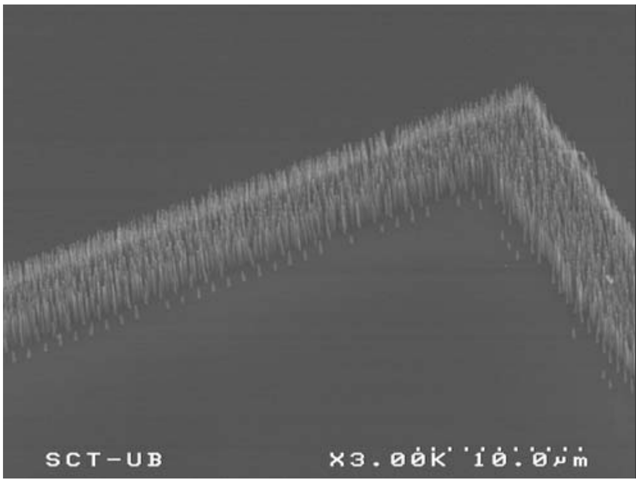

Figure 1: 45º tilted 30kV SEM (Hitachi S-4100) view of Ni dots matrix of CNTs surrounded by Ni nanoparticle frame.

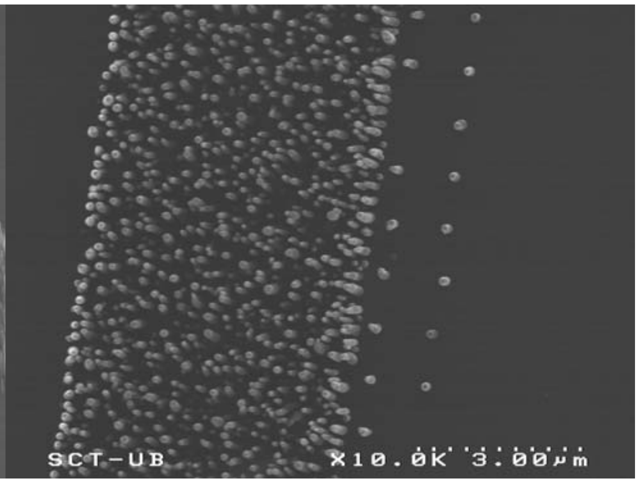

Figure 2: 30kV SEM upper view of Ni dot matrix of CNT surrounded by Ni nanoparticle frame. Only the two first rows of the matrix produce CNT due to the proximity effect.