

# Oriented Growth of Single-Walled Carbon Nanotubes from the Bottom of Mesoporous Silica Film

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Vertically oriented single-walled carbon nanotubes (SWNTs) can be an ideal field electron emitter which realizes lower threshold voltage and higher electric current than microtips of Si or metals. In this study, SWNTs are vertically oriented using mesoporous silica film as a guide of SWNTs growth. Figure 1(a) is a schematic image of the vertical orientation. Co film was fabricated by sputtering deposition on a Si substrate. Mesoporous silica (SBA-16,  $Im\bar{3}m$  cubic) film was coated on it by dip-coating [1]. The thickness of the Co film was changed from 1 to 100 nm (see table 1). After reduction of Co in a flow of 3% $H_2$ /Ar, catalytic CVD of ethanol was performed at 750°C for 10 minutes at 10 Torr.[2] Raman spectrometry and FE-SEM were used for the characterization of SWNTs and film. Table 1 shows the results characterized by Raman spectrometry. When the Co film was thin, high-purity SWNTs were synthesized. Figure 1(b) indicated that Co did not aggregate and was not transferred from sputtered position, a bottom of mesopore, when the Co film thickness was 1nm. The position of Co was localized between Si substrate and SBA-16 film. Several characterizations lead us to conclude that SWNTs are grown along the pores of the SBA-16 film and vertically oriented, as illustrated in Fig. 1(a).

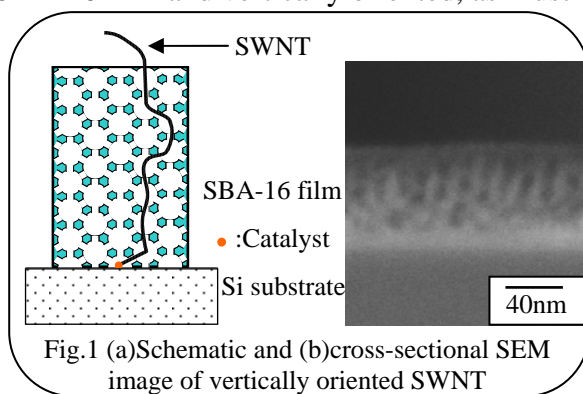


Table1 The influence of Co thickness and SBA-16 film

Co film thickness	SBA-16 film	
	With	Without
1nm	SWNTs	SWNTs
2nm	—	SWNTs
5nm	SWNTs	No CNTs
10nm	SWNTs	No CNTs
20nm	CNTs	No CNTs
50nm	CNTs	No CNTs
100nm	CNTs	No CNTs

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**References:** [1] Y. Murakami, S. Yamakita, T. Okubo, and S. Maruyama, *Chem. Phys. Lett.*, **375**, 393 (2003)

[2] Y. Murakami, Y. Miyauchi, S. Chiashi and S. Maruyama, *Chem. Phys. Lett.*, **377**, 49 (2003)

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