# Synthesis of carbon nanotubes using self-organized catalytic particles

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We synthesize vertically aligned carbon nanotubes (CNTs) by the plasma-enhanced chemical vapor deposition (PECVD) method using catalytic particles arranged in a concentric pattern. Iron oxide nanoparticles, the average diameter of which is approximately 5 nm, are synthesized by the polyol method [1] and they are used as catalysts for the synthesis of CNTs. The nanoparticles are dispersed in benzene and the particle-dispersed solution is dropped into a circular cavity (diameter 8 mm, depth 5 mm), which is placed on a hot plate set at 50ºC. During the evaporation of benzene, the particles form concentric circular patterns on the bottom plate of the cavity via the so-called coffee-ring effect [2]. Carbon nanotubes are synthesized with the self-organized catalytic particles by $CH_4/H_2$ PECVD. It is confirmed by SEM observations that vertically aligned CNTs are selectively produced on the concentric patterns formed by the catalytic particles. We analyze the effect of the line width and the line-to-line spacing of concentric patterns, which can be controlled by changing the conditions of the evaporation process such as the temperature, the cavity diameter and the initial particle concentration, on the growth rate of aligned CNTs.

**References:**

[1] A. Baliyan *et al*., *Chem. Phys. Lett.* **519–520**, 78 (2012).
[2] R. D. Deegan *et al*., *Nature* **389**, 827 (1997).