# FCCVD growth of SWCNTs by spark discharge based metallic and bimetallic catalysts particles

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## Abstract

Floating catalyst chemical vapor deposition (FCCVD) is one of the most widely used technique for CNT synthesis. The catalysts for CNT synthesis in FCCVD are strongly tied with the CNT yield, morphology, and chirality. However, the catalyst aerosol in conventional FCCVD, is made with the pyrolysis of volatile organometallic compounds, e.g. ferrocene. This conventional process of catalyst fabrication in FCCVD, not only limits the composition of the catalyst but also hinders to regulate the concentration and configuration of the catalyst. Here, we introduce a novel rod to tube type spark discharge generator (R-T SDG) to synthesize time stable metallic and bimetallic catalyst nanoparticles for the FCCVD growth of SWCNTs. Based on the physical evaporation-nucleation-condensation process, spark discharge generation of nanoparticles is a low-cost and scalable gas phase method that can produce variety of highly pure metal or alloy nanoparticles with controllable number concentration and particle size distribution [1,2]. We synthesized monometallic Fe and Co as well as bimetallic Co-Ni catalyst particles from R-T SDG. These particles were introduced inside a vertical FCCVD reactor along with ethylene as carbon source to grow high quality SWCNT. At the outlet of the reactor SWCNTs were deposited in gas phase on membrane filter to form CNT films which can be applied in high-performance transparent electrodes. The sheet resistance of 90% transparent CNT films at 550 nm wavelength after doping with 16 mM $AuCl_3$ varies in the range 180-240 Ω $sq^{-1}$ as shown in the Fig.1. This novel technique has great potential in academic and industrial fields of CNT synthesis and their applications.

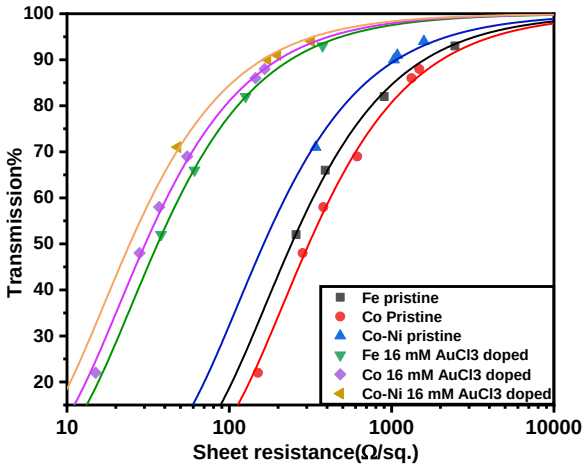


**Fig. 1.** Optoelectronic performance of SWCNTs synthesized in gas phase inside a vertical FCCVD reactor using spark produced Fe, Co and Co-Ni catalyst nanoparticles.

References

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[2] Mustonen, K., Laiho, P., Kaskela, A., Zhu, Z., Reynaud, O., Houbenov, N., … Kauppinen, E. I, Applied Physics Letters, *107*(1) (2015).