NEC Realizes Control of Position & Diameter of Carbon Nanotube

Technology that contributes to electronic devices utilizing carbon nanotubes

NEC Corporation today announced the development of a diameter/position-controlled carbon nanotube ("CNT") growth technique that is based on conventional electron beam ("EB") lithography. This technique will provide a practical method for controlling the position and diameter of each CNT. NEC expects this result will promote the research and development of high-performance CNT electronic devices.

This result was achieved through the development of the following key technology:
Tiny, iron-doped resist dots were made into a pattern using EB lithography. Thermal annealing was subsequently carried out to segregate the iron nanoparticles in the dot pattern. Due to the original content of the iron dopant and the size of the resist pattern, the diameter of the particle can be effectively controlled well below the lithography limit.

Control of the position of resist dots is enabled through EB lithography, which uses high-resolution EB resist called "calixarene". Iron nanoparticles are precisely placed on the point where the original resist dot has been formed.

Single-walled carbon nanotubes ("SWNT") with a designed diameter can be grown from the iron nanoparticles using the high-yield CNT growth technique based on chemical vapor deposition ("CVD").

Using this lithographically-directed nanoparticle synthesis method, iron particles having a 1.7±0.6 nm diameter distribution were successfully patterned at a 100-nm pitch within a positioning accuracy of ±5 nm. CNTs were grown by CVD at 750°C using ethanol. As a result a CNT diameter distribution of 1.3±0.4 nm was obtained. NEC has already confirmed that the growing direction of CNTs can be controlled by applying an electric field during CVD growth. These techniques will enable NEC to grow CNTs with individually controlled position, diameter, and orientation.

These results are expected to promote the research and development of CNT transistors as high-performance electrical devices. NEC will continue to work on advancements in CNT control technology, electric characteristic control, device structure design, and fabrication process development with the aim of realizing a CNT transistor by 2010.

This result will be announced on September 4 at the 2004 autumn meeting of the Japan Society of Applied physics being held from September 1 to 4 in Sendai, Japan, and at the 2004 international conference on Micro- and Nano-Engineering being held from September 19 to 22 in Rotterdam, Holland. Japan Fine Ceramics Center (JFCC) and the New Energy and Industrial Technology Development Organization (NEDO) commissioned this research as a part of the Nanocarbon Application Product Creation Technology Project.