Directed Growth of Carbon Nanotubes Across Gaps

Single-walled carbon nanotubes grow aligned along applied electric fields.

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An experiment has shown that when single-walled carbon nanotubes (SWNTs) are grown by chemical vapor deposition in the presence of an electric field of suitable strength, the nanotubes become aligned along the electric field. In an important class of contemplated applications, one would exploit this finding in fabricating nanotube transistors; one would grow SWNTs across gaps between electrodes that would serve, subsequently, as source and drain contacts during operation of the transistors.

In preparation for the experiment, a multilayer catalyst comprising a 20-nm-thick underlayer of iridium (platinum group), a 1-nm-thick middle layer of iron, and a 0.2-nm-thick outer layer of molybdenum was ion-beam sputtered onto a quartz substrate. A 25-μm-diameter iron wire was used as a shadow mask during the sputtering to create a 25-μm gap in the catalyst. Then electrical leads were connected to the catalyst areas separated by the gap so that these catalyst areas would also serve as electrodes.

The substrate as thus prepared was placed in a growth chamber that consisted of a quartz tube of 1-in. (2.54-cm) diameter enclosed in a furnace. SWNTs of acceptably high quantity and quality were grown in 10 minutes with methane at atmospheric pressure flowing through the chamber at a rate of 1,000 standard cubic centimeters per minute at a temperature of 900°C. To prevent oxidation of the SWNTs, the chamber was purged with 99.999-percent pure argon before and after growth, and the chamber was cooled to <300°C before opening it to the atmosphere after growth.

When no voltage was applied across the gap, the SWNTs grew in random directions extending out from the edges of the catalyst at the gap. When a potential of 10 V was applied between the catalyst/electrode areas to create an electric field across the gap, the SWNTs grew across the gap, as shown in the figure.

This work was done by Lance Delzeit and Meyya Meyyappan of Ames Research Center and Ramsey Stevens and Cattien Nguyen of Eloret Corporation. Further information is contained in a TSP (see page 1).
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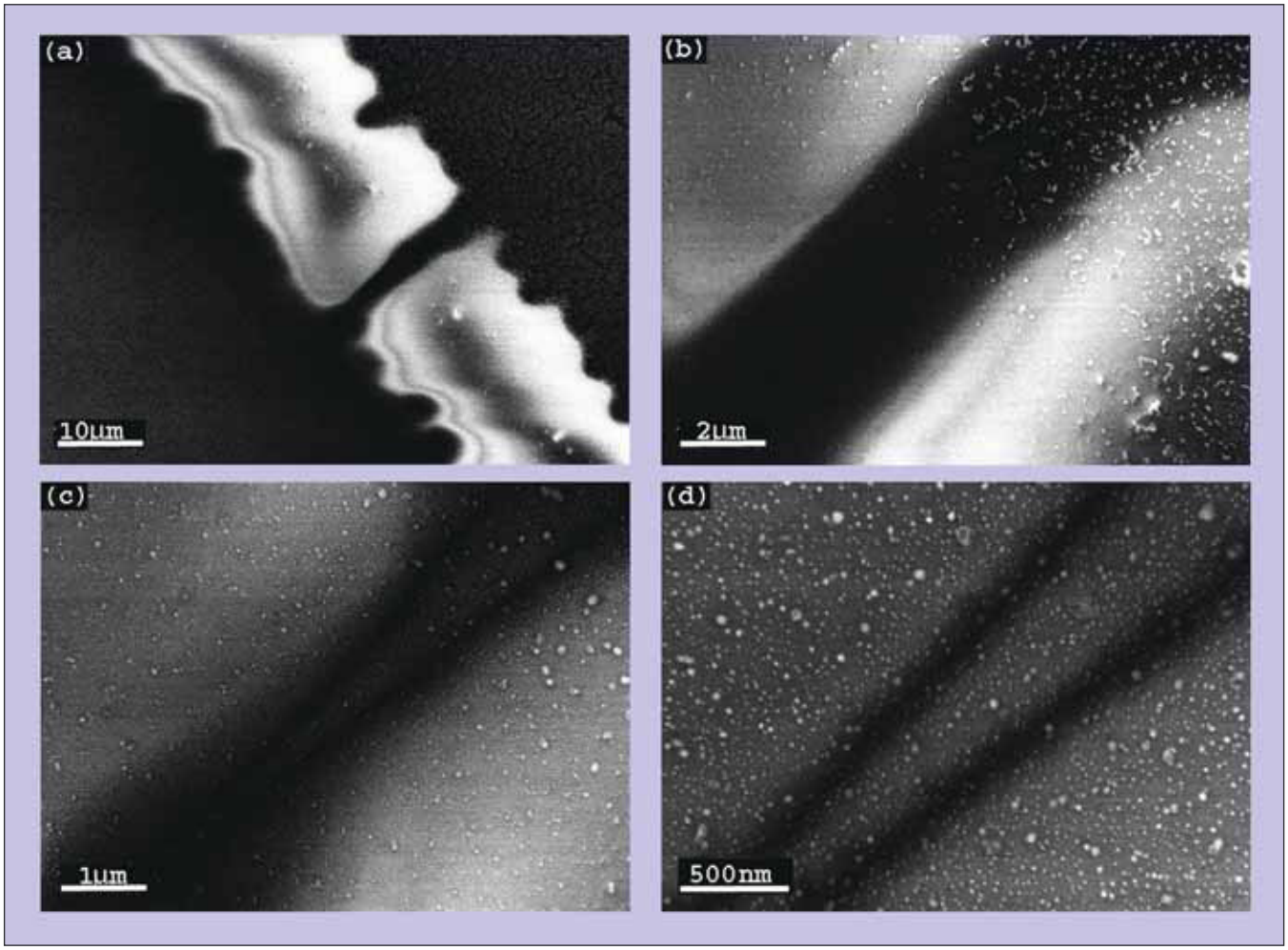

These **Scanning Electron Micrographs** show SWNTs that were grown to bridge a 25-μm gap between two catalyst/electrode areas. Progressively higher magnification of one of the bridges reveals that it consists of two closely spaced SWNTs.