What is Below the Support Layer Affects Carbon Nanotube Growth: an Iron Catalyst Reservoir Yields Taller Nanotube Carpets

Efrat Shawat¹, Vladislav Mor³, Landon Oakes², Yafit Fleger¹, Cary L. Pint², and Gilbert D. Nessim¹,*

¹ Department of Chemistry and Institute for Nanotechnology, Bar-Ilan University, Ramat Gan, 52900, Israel

² Department of Mechanical Engineering and Interdisciplinary Materials Science Program, Vanderbilt University, Nashville, TN 37235, USA

³ Department of Physics and Institute for Nanotechnology, Bar-Ilan University, Ramat Gan, 52900, Israel
**Supporting Information:**

**Figure 1** AFM measurements of samples annealed for 10 minutes at 790°C with and without reservoir. We can observe the large particles on the sample with the Fe reservoir.
Figure 2 Raman spectroscopy measurements taken samples with and without Fe reservoir after 5 min anneal at 790°C. The G/D ratios are comparable.
5 min anneal at 790 degrees- with "Fe reservoir"

5 min anneal at 790 degrees- without "Fe reservoir"

**Figure 3** (a) and 2(b) show top-view HRSEM images taken for both Fe reservoir and the non-Fe reservoir samples, respectively, after a 5 minute annealing period, at 790° (the magnifications are 50,000, 100,000 and 200,000 respectively).
Figure 5 HRTEM images showing the crystalline CNT structure for samples with and without the Fe reservoir for annealing durations between 2-30 min. We can see that the CNT diameters are smaller for the sample with the Fe reservoir compared with the non-reservoir sample. This result correlates with the annealing experiments and support the mechanism described in the text.
Figure 6 SEM images showing the CNT carpets for samples with and without the Fe reservoir with 5 min anneal for 15 min growth durations at 790°C. (1) Fe 10 nm/Al₂O₃ 30 nm/Fe 1.2 nm (2) Fe 10 nm/Al₂O₃ 10 nm/Fe 1.2 nm (3) Fe 10 nm/Al₂O₃ 5 nm/Fe 1.2 nm (4) Fe 10 nm/Al₂O₃ 3 nm/Fe 1.2 nm (5) Al₂O₃ 3 nm/Fe 1.2 nm
Figure 7 SEM images showing the result of a 5 minute anneal followed by a 20 second growth (at 790 °C). The sample without reservoir (left) exhibited only micron-long entangled CNTs while the sample with reservoir (right) exhibited a 15 μm-tall carpet of vertically aligned CNTs.