Water-assisted catalytic VACNT growth optimization for speed and height

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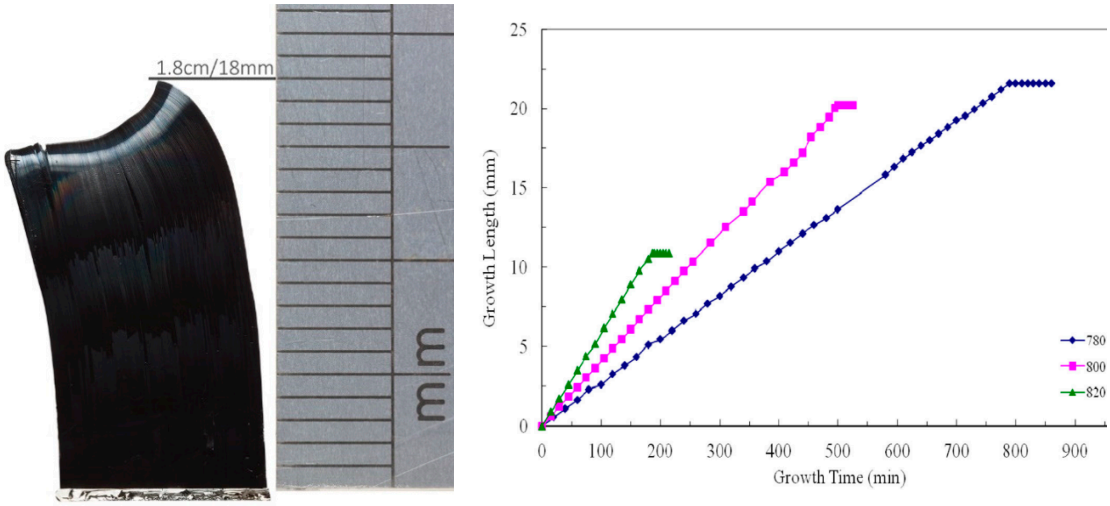
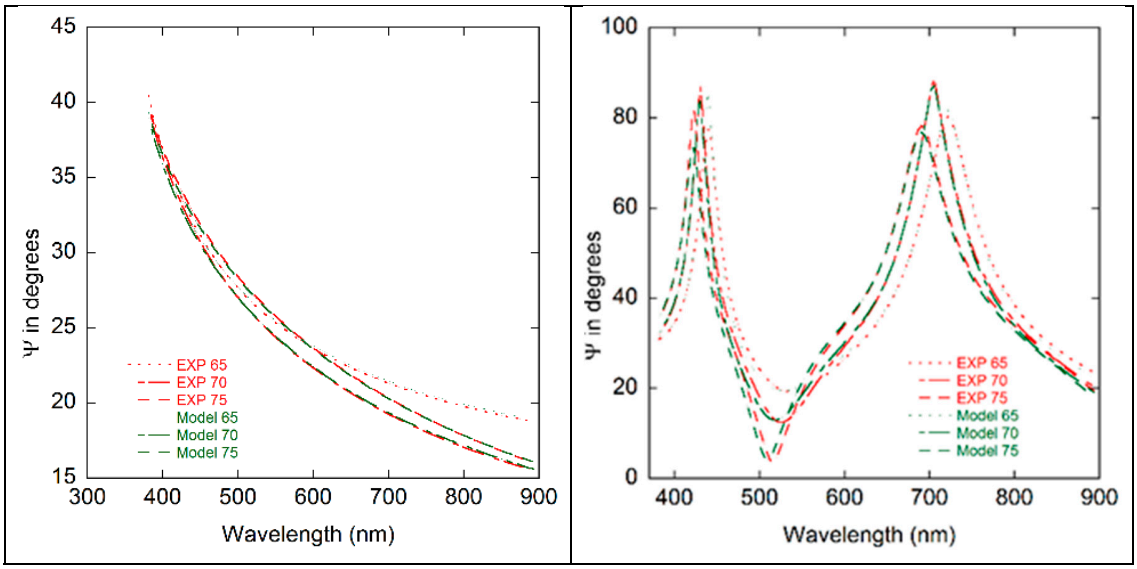
Supporting Information

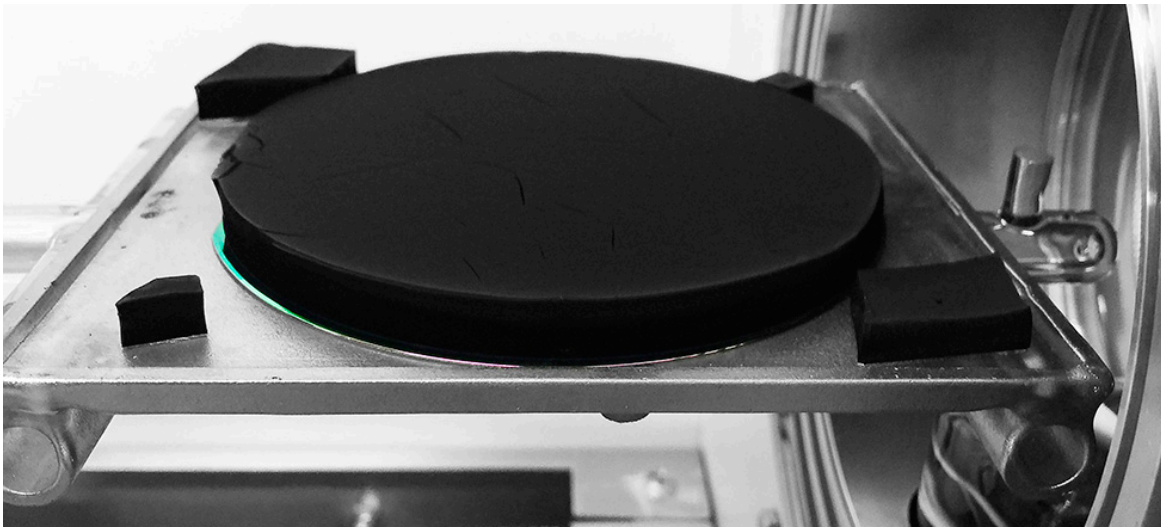
SI Figure 1: Fully automated medium size FirstNano® EasyTube® 3000 VACNT and thermal oxide growth system with a 5″ diameter and 54 cm long horizontal quartz process tube with a 20″ long heating zone having a 4″ load and end zone and a 6″ center zone length.



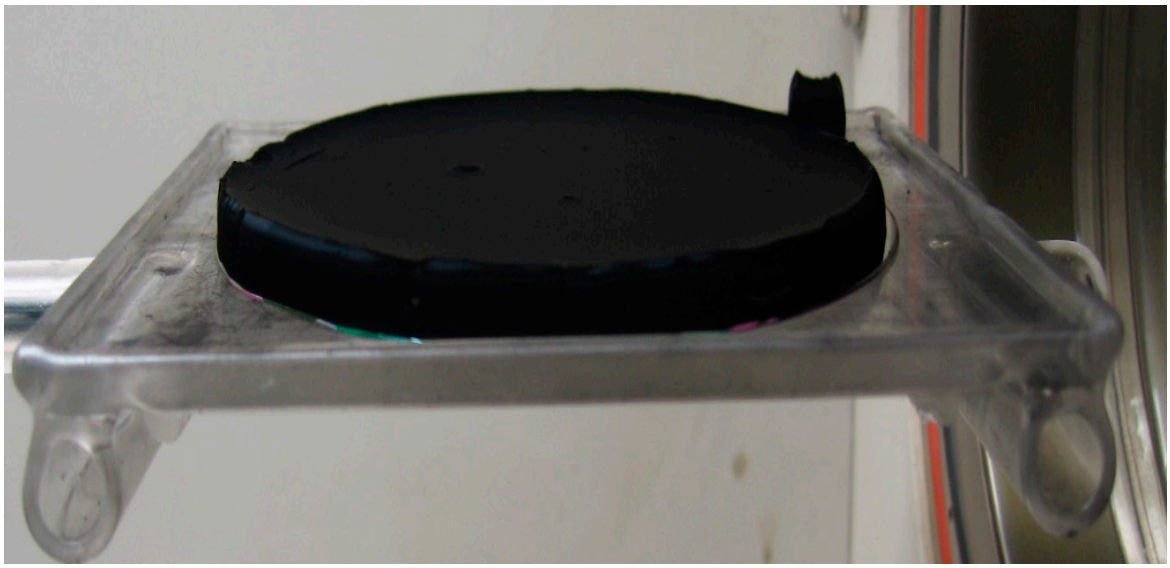
SI Figure 2: (left) VACNT height at 750 °C on 1 cm size Si wafer, (right) VACNT height for Process A at temperat of 780-820 °C.



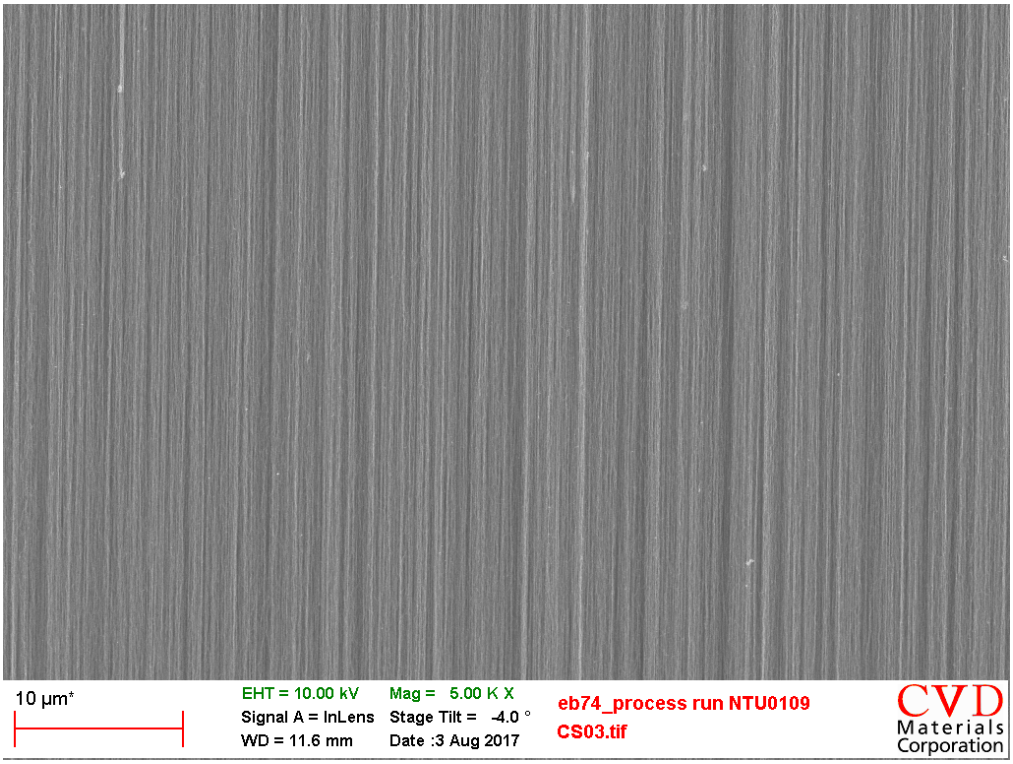
SI Figure 3. Ellipsometry analysis shows the thickness of iron catalyst on substrates. (Left) Process A, Process B: 2.5 nm Fe/20 nm Al_2O_3/400 SiO_2 wafer, (Right) Process C: 1.5 nm Fe/10 nm Al_2O_3/20 SiO_2 wafer.



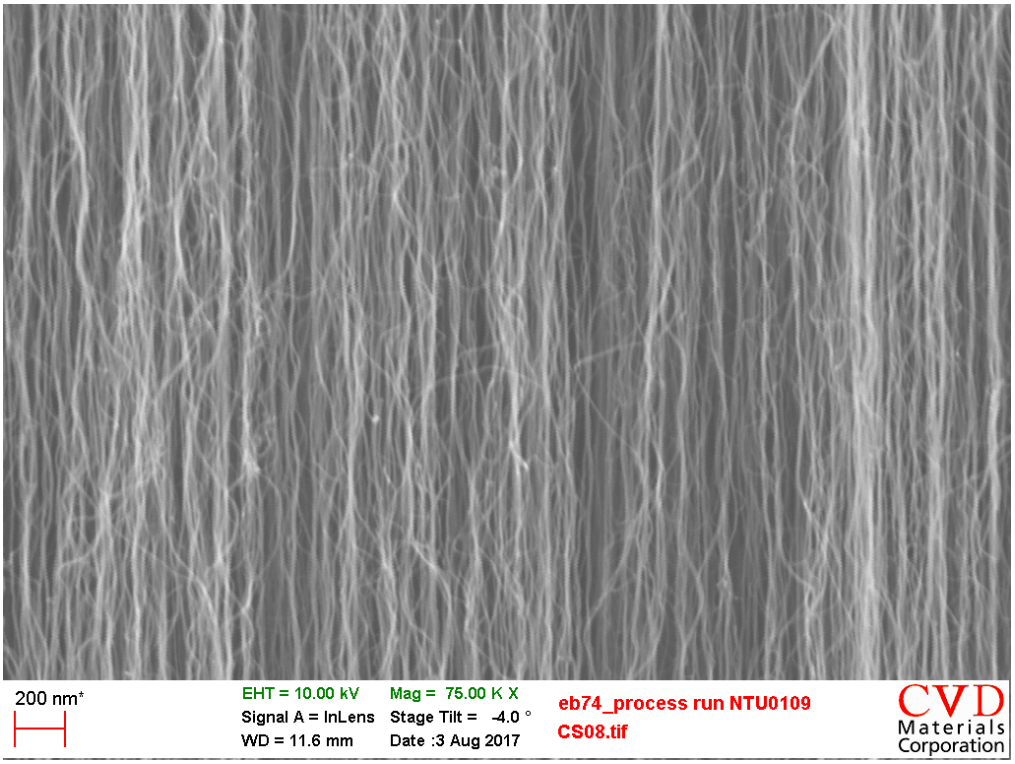
SI Figure 4: 10 mm thick VACNT on 4″ Si wafer with a ~ 40 μm thick crusted top (growth process A).



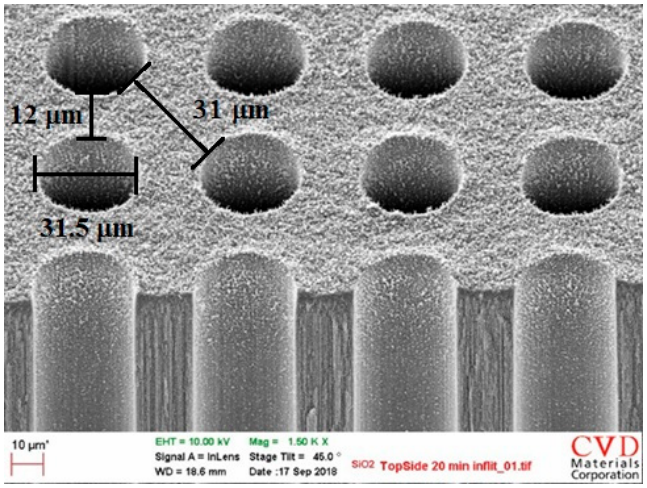
SI Figure 5: 4 mm thick, more fluffy VACNT growth on full 4″ Si wafer with a ~ 20 μm thick crusted top of (Process B).



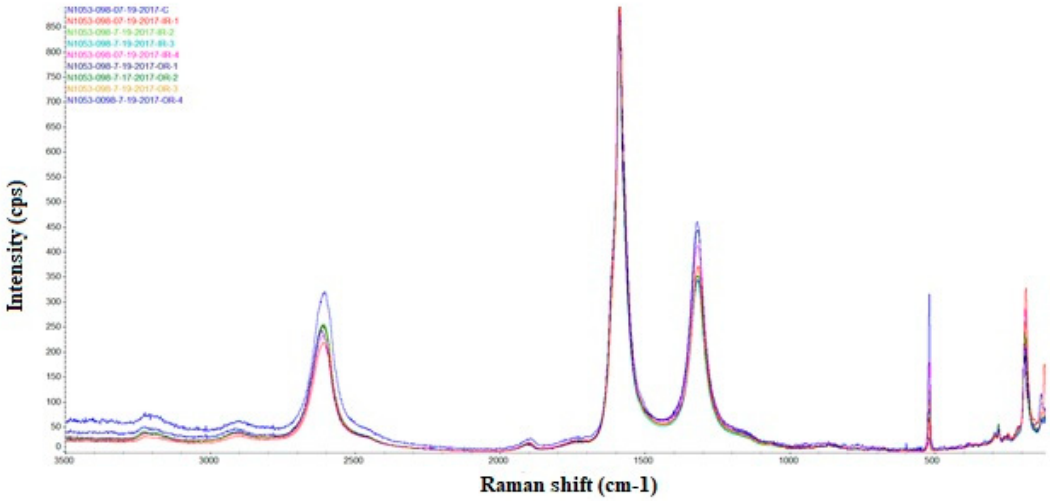
SI Fig. 6a: *Low-resolution SEM images of VACNT sample grown with Process C.*



SI Fig. 6b: High-resolution SEM images of VACNT sample grown with Process C.



SI Figure 7: SEM images of VACNT (growth process C +carbon infiltration process highlighting the remaining top 5-10 µm thick "crust" layer



SI Figure 8: Raman spectra at different points (center, inner radius, and outer radius) showing the RBM of VACNTs grown on 4-inch Si wafer for Process C.