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High Performance Flexible Nanotube Electronics

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Fundamental studies of charge transport through individual single walled carbon nanotubes (SWNTs) reveal remarkable room temperature properties, including mobilities more than ten times larger than silicon, current carrying capacities as high as 10^9 A cm^{-2} and ideal subthreshold characteristics in single tube transistors. The implications of these behaviors could be significant for many applications in electronics, optoelectronics, sensing and other areas. Devices that use single SWNTs as functional elements might not, however, form a realistic basis for these technologies, due to their small current outputs and active areas as well as the extreme difficulties in synthesizing and accurately positioning large numbers of individual, electrically homogeneous tubes. Here we present a scalable approach to high performance electronics that uses dense, perfectly aligned arrays of long, perfectly linear single walled carbon nanotubes (SWNTs) as an effective thin film type semiconductor suitable for direct integration into field effect transistors. The large numbers of SWNTs enable excellent device level performance characteristics and good device-to-device uniformity, even with SWNTs that are electronically heterogeneous. Measurements on p- and n-channel transistors that involve as many as ~1,000 SWNTs reveal device level mobilities, scaled transconductances and current outputs as high as ~1,100 cm^2 V^{-1} s^{-1}, ~3,000 S m^{-1} and ~100 mA, respectively. PMOS and CMOS logic gates and mechanically flexible transistors on plastic provide examples of devices that can be achieved. Collectively, these results may represent a realistic route to large scale integrated nanotube electronics.