Heterogeneous integration of nanowires and nanotubes on CMOS

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We are ushering in the new era of nanotechnology with great promise but also serious challenges. Exciting results in the next-generation transistors, label-free biological and chemical sensing, single cell analysis, and medical diagnostics have been demonstrated using an incredibly diverse palette of nanomaterials: CNTs, Si, Ge, Au, Ag, Pt, ZnO, GaN, InP, *etc*. However, the promise of nanotechnology cannot be fully realized until functional devices and systems can be made from these nanomaterials, in a reliable and low-cost manner.

Here we suggest the use of standard CMOS technology for heterogeneous assembly of various nanomaterials on the same CMOS chip. CMOS chips serve as electroactive functional substrates for real-time *in-situ* feedback control over the location and quantity of nanowires and nanotubes being assembled. Following the assembly and contact formation, CMOS chips provide for individual access to nanowire sites for low-noise sensor readout and signal processing.

As a proof of concept, single walled carbon nanotubes (SWNTs) and InP nanowires have been assembled directly on CMOS using the proposed approach. Applications ranging from chemical sensing to image sensing have been demonstrated. We will discuss the challenges (yield, process variations, *etc*.) and opportunities (novel sensing and computing paradigms) for such a technology and its promise for the future.