On Demand Micro and Nanoelectronics using a Fab in a Box Micro Factory

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Abstract:

Directed assembly is a new additive, bottom-up semiconductor manufacturing process in which nanoscale and microscale structures are built by precisely assembling nanoparticles, molecules, or liquids for making passive and active electronic components, trace, and interconnects at the nano and microscale [1]. The technique eliminates etching, vacuum deposition, and other chemically intensive processing by utilizing the directed assembly at ambient temperature and pressure at a rate of one circuit layer per minute on a 4-inch wafer. This technology has demonstrated the manufacturing of devices utilizing inorganic (or organic if desired) nanomaterials such as conductors including metals, silicon, III-V and II-VI semiconductors, and low and high k dielectrics such as SiO2, Al2O3, and HfO2 to make electronics. Single-crystal conductors and semiconductors [2] can be printed and sintered at ambient temperature or by using thermal sintering (for particles larger than 20 nm). The nanoparticles are suspended using colloid chemistry, and the post-assembly crystallization utilizes different sintering conditions if needed. The manufacturing of transistors with an on/off ratio greater than 10^6 has been demonstrated. The process begins with substrate patterning using lithography followed by selective surface functionalization to enable site-specific particle or liquid deposition. The assembly of nanoparticles onto the functionalized substrate is enabled by applying external fields such as electrophoretic, dielectrophesis, convective, fluidic, or capillary forces that drives particles to the patterned sites to make complex, multi layer, multi-material devices. After each layer, processes such as sintering and annealing fuse the nanoparticles into continuous, functional films. All of the required manufacturing processes are integrated in a fully automated platform Fab-in-a-Box (FIBOX) that enables lithography, directed assembly and sintering.

The presentation will show the repeatable manufacturing and yield of micro and nanoelectronics including logic made using a fully additive process down to the submicron scale without using etching, vacuum, or chemical reactions. This additive high-throughput manufacturing solution can enable low-cost trace, interconnect, passive, and active components manufacturing while reducing the carbon foot print by 10-20 times.

References

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