Mole-Nano-Micro Electronics: Challenges and Solutions at the Reach of the Current Silicon Technology

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Assuming with Feynman that single atoms can be used as elementary devices for computation, this would give a maximum density of the order of 10^{15} cm^{-2}equivalent information units for a planar arrangement. If the chemical composition of the surface is fixed and any information change is simply associated with a conformation change between two possible states of any given surface atom, the above density would result in a maximum allowed density of just 1 Pbit cm^{-2}—the peta scale integration (PSI).

The manipulation of information on the atomic scale, however, requires the use of macroscopic-scale apparatuses that may be operated only at a negligible rate. Fundamental considerations show instead that electrons can be lodged in configurations with densities of the order of 10^{12} bit cm^{-2} (the tera scale integration, TSI) and in this arrangement the already existing mesoscopic-scale apparatuses in the giga scale integration (GSI) can control and sense their flow.

Even though there is no idea for the full exploitation of the performances of such devices, the TSI density is at the reach of the present technology. Rather than scaling down of conventional CMOS (complementary metal-oxide-semiconductor) circuits, the TSI may almost be achieved via a hybrid architecture where a silicon-based CMOS circuit controls a nanoscopic crossbar structure hosting in each cross-point a collection of functional molecules able to mimic by themselves the behaviour of a device.

The hybrid (silicon+molecules) route, however, poses severe problems:
(i) the set up of an economically sustainable technology for the preparation of 10^{11} cross-points cm^{-2} or more, (ii) the grafting of the functional molecules to those cross- points via batch processing, (iii) the demultiplexing of the addressing lines to allow their linkage to the microelectronic circuit; and (iv) the design, synthesis and electrical characterization of the functional molecules, have been identified as the most important ones.

This paper is devoted to discuss the severe challenges the Mole-Nano-Micro hybrid architecture posses and to present the solutions that have been found.

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