FEASIBLE ARCHITECTURES FOR MOLECULAR ELECTRONICS

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The integrated circuit, manufactured by optical lithography, has driven the computer revolution for four decades. If we are to continue to build complex systems of ever-smaller components, we must find a new technology that will allow massively parallel construction of electronic circuits at the atomic scale. To do so we must develop both the molecular electronics building blocks and CAD algorithms for such a reconfigurable technology.

The technical problem we face is to make extremely small electronic components (at the atomic scale), use very large numbers of these components to make very complex circuits, but manufacture these circuits at much less cost than today's integrated circuits. This requires many disciplines to work together. To make them function at the smallest scales we use quantum physics. To achieve massive complexity we use computer architecture. To keep them inexpensive we use low mechanical precision and do self-assembly with chemistry. And to deal with the inevitable defects of chemical self-assembly we use defect tolerant design algorithms.

One potentially scalable device consists of two crossed nanowires sandwiching an electrically addressable molecular species. The approach is extremely simple and inexpensive to implement, and scales from wire dimensions of several micrometers down to nanometer-scale dimensions. This structure can be used to produce crossbar switch arrays, logic devices, memory devices, and communication and signal routing devices. The device is either partially or completely chemically assembled, and the key to the scaling is that the location of the active devices on the substrate are defined after the devices have been assembled, not prior to assembly. This architectural approach allows us to address the functions of interconnect, memory, logic and I/O.

The key task of the architectural community in the immediate future is to develop a sense of the trade-offs between the computational costs of CAD algorithms to repair defects and the manufacturing costs of avoiding defects in the first place. Biology has struck one balance. We need to find the balance for nanotechnology.