Molecular Electornics: Progress and Challenges

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A range of new concepts for devices, fabrication techniques, and system architectures are emerging today under the general heading of "nanoelectronics" that may eventually provide the basis for continuing advances in information technologies. One of such potentially promising concepts is molecular electronics.

Using molecules as possible elements for electronic devices has an enormous appeal. In the size hierarchy of nature, molecules stand just above atoms making them ideal ultimate choice for ever-shrinking electronic devices. Molecules can be inexpensively synthesized with the exactness not conceivable for standard top-down patterning techniques. Synthetic chemistry offers vast diversity of molecular objects as well as certain degree of fine tweaking of electronic structure similar to the doping of semiconductors.

In this talk I will present a review of progress and challenges of molecular electronics. The design of individual molecular devices and the concepts of overall computing architecture are closely related. One of the simplest ideas is to build a computer that imitates the operation of modern computers with CMOS devices replaced by smaller molecular transistors. Many interesting concepts of molecular devices including switches, diodes and transistors have been demonstrated in research labs. Despite this promising functionality all devices at single molecule level suffer from similar problems: the exactness of molecular structure is lost at the point of attachment of molecules to contact leads. The contact is the bottleneck ruining the precision of the molecular device! Adding to the problem, the modern theoretical models have yet to satisfactorily agree with the experiments.

More sophisticated architectures are proposed to circumvent the expected imperfection of the molecular devices and/or to use molecular self-assembly at the lowest level of integration. Characteristic of any new area, it is difficult to discern which of these concepts has the potential to provide a technological basis for information technologies of the future.