Bio-Inspired Molecular Nanoelectronics

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Molecular (nano)electronics aims at assembling nanoscale electronic devices using functional molecules by a bottom-up approach. Macromolecules of biological origin (proteins and DNA) can play, in this context, a major role for a number of reasons. Among the huge variety of functional activities that they perform, those involving electron transport are typical of special classes of proteins called redox metalloproteins. Their functional activity consists in shuttling electrons between molecular partners for accomplishing different physiological tasks. Natural evolution has optimized their efficiency, along billions of years, providing molecular elements highly specialized in transferring electrons. The presence of one or more redox ion in their active site is connected with metalloproteins electron transport properties, and makes them electrically gateable, imparting features typical of a single-particle transistor. On the other hand, Dna is endowed with very powerful self-recognition and self-assembling properties which appear extremely useful for building molecular scale circuitry. Furthermore, Dna can be promptly manipulated and modified both by enzymatic and chemical approaches, and can be synthesized as a hybrid molecule along with synthetic polypeptides, to enrich the construct in chemical functionalities. In this talk a bio-inspired approach to the self-assembling of complex hybrid nanocircuits starting from lithographically defined nanoelectrodes will be presented, along with the results of investigations aimed at characterizing and exploiting single metalloproteins (the bacterial protein azurin) as single molecule transistors[1]. Moreover, to the use of DNA and synthetic Dna-polypeptide hybrids to buid molecule-templated metal nanowires[2,3] will be demonstrated. A novel approach aimed at imparting chemical specificity to individually addressable inorganic nanostructures will be also introduced which eventually should allow the self-assembling of complex bio-molecule based nanocircuitry without the need of direct manipulation for positioning molecules in between electrodes.

1 A. Alessandrini, M. Salerno, S. Frabboni, P. Facci “Single-metalloprotein wet biotransistor” Appl. Phys. Lett., 86, 133902, (2005).
2 L. Berti, A. Alessandrini, and P. Facci “DNA-Templated Photoinduced Silver deposition” J. Am. Chem. Soc. 127, 11216, (2005).
3 L. Berti, A. Alessandrini, P. Facci “Controlled DNA-templated metal deposition: towards ultrathin nanowires”, J. Nanosci. Nanotech., in press, (2006).