Scientists demonstrate a breakthrough in fabricating molecular electronics

May 4 2006

Scientists from Philips Research and the University of Groningen (the Netherlands) have for the first time fabricated arrays of molecular diodes on standard substrates with high yields. The molecular diodes are as thin as one molecule (1.5 nm), and suitable for integration into standard plastic electronics circuits. Based on construction principles known as molecular self-organization, molecular electronics is a promising new approach for manufacturing electronics circuits in addition to today's conventional semiconductor processing. Details of the technology are presented in the 4 May 2006 issue of *Nature*.

Although still a relatively new field, molecular electronics can be regarded as the next evolutionary stage for plastic electronics. Molecular electronics holds the potential to fabricate elements for electronics circuits with a functionality that is embedded in just a single layer of molecules.

Instead of using photolithography or printing techniques to etch or print nano-scale circuit features, molecular electronics can be engineered to use organic molecules that spontaneously form the correct structures via self-organization. Nature provides the inspiration by being very efficient at using self-organized structures for conducting charge – e.g. in the photosynthesis in plants and nerve systems in mammals – and assembling such structures with precision beyond the capabilities of any man-made machine or process.

"Molecular electronics will not compete with current silicon-based IC

technologies," explains Dago de Leeuw, a Research Fellow within Philips Research and member of the joint research team that made the breakthrough. "Molecular electronics could be an interesting option for manufacturing plastic electronics. Plastic electronics is very promising for the manufacture of electronics where low temperature or low cost in-line processing techniques are required."

While there have been many research activities in this field over the last 10 to 20 years, a reliable way of building molecular electronics had not been found. Well-defined molecular-electronics-based diodes can only be realized when the molecules are sandwiched between two metallic (e.g. gold) electrodes. To this end functional molecules are used that (under the proper conditions) spontaneously form a densely-packed monolayer on the bottom electrode. Many approaches have attempted to simply deposit a metal electrode directly on to this monolayer. However, this approach results in shorting, caused by contacts forming between the electrodes, since the monolayer is only 1 to 2-nm thick.

The technology developed by the scientists at the University of Groningen and Philips Research uses monolayers that are confined to predefined holes in a polymer that has been applied on top of the bottom electrode. The key to their success is the deposition of an additional plastic electrode layer on to the monolayer prior to the deposition of the metallic electrode. The plastic electrode protects the monolayer and as such enables a non-detrimental deposition of the gold electrode.

"Based on a molecular self-assembly process we have developed a reliable way to fabricate well-defined molecular diodes," says Dr Bert de Boer, the Assistant Professor within the Materials Science CentrePlus at the University of Groningen that leads the joint research team. "It will enable us, for the first time, to do reliable and reproducible measurements on molecular junctions, which is essential for the exploration of the potential applications of molecular electronics."

The success of this research project is further proof of the leading position that the University of Groningen and Philips Research have in plastic electronics research. It also provides a strong foundation to develop new applications for electronic elements in which the functionality has been confined to only one molecular layer.

Source: Philips Research