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Fresh spin on DNA electronics

DNA conducts electricity and has been proposed as a wire for molecular electronics. Now calculations show that it will preserve spin alignment in a spintronic device.

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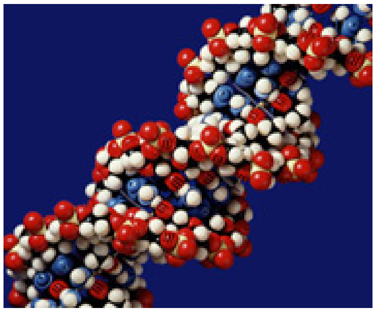

Spintronics, a supercharged form of electronics that makes use of electron spin to encode information, might be able to use molecular wires made from DNA. This remarkable claim follows from a theoretical study by Michael Zwolak and Massimiliano Di Ventra of Virginia Polytechnic Institute and State University, who have looked at how electrical currents flow down a DNA strand hooked up to two metal electrodes[1].

The idea behind spintronics is that the spin of the electrons is used as a handle to control the current. To make this work, it is necessary to be able to create and transmit spin-polarized currents, in which all the electrons retain pre-assigned spins ('up' or 'down').

Because the spin of an electron determines the orientation of its magnetic moment, the control of a current in spintronic devices can be done magnetically. A spin valve, for example, is a device that can be 'opened' or 'closed' to electron flow by flipping the magnetic field of ferromagnetic channels in the device. One magnetic 'filter' aligns the spins, and a second one blocks the current if its field is antiparallel to the first. It is rather like sending polarized light through two polarizing filters: the light is transmitted when the directions of polarization are aligned, but becomes totally blocked when they are twisted at 90 degrees.

Zwolak and Di Ventra say that a short length of DNA sandwiched between two iron or nickel contacts can act as a spin valve. It is not a perfectly open-and-shut affair: rather, the current is decreased by up to 26% when the magnetic fields of the two ferromagnetic nickel contacts are switched from parallel to antiparallel. This could be enough, however, to distinguish between the spin-up and spin-down states written into a spin-polarized current mdash that is, to lsquoreadrsquo and lsquowritersquo information.

One critical question for a putative spin valve is whether the electrons can travel between the magnetic contacts without being scattered and losing the coherence of their spins. Zwolak and Di Ventra estimate that, for a short DNA molecule made up of about 30 base pairs, this source of decoherence should not be too strong, and should not obscure the difference in current for parallel and antiparallel magnetic fields.

Most spintronic devices postulated or made so far have used metals or magnetic semiconductors to carry and control the current. Using DNA raises the possibility of a spintronic technology on the molecular scale. It is not a far-fetched idea: the electrical conductivity of strands of DNA suspended between metal contacts has already been measured, and there are well-developed chemical and biotechnological methods for manipulating and arranging DNA strands into nanoscale structures. Zwolak and Di Ventra say that the spin-dependent transport that they predict in DNA should be experimentally observable, and such experiments should be well within the reach of current techniques.

References

1. Zwolak M. amp Di Ventra M. DNA spintronics. *Appl. Phys. Lett.* **81,** 925–927, (2002).