spacer applications and procedures for templating either the acceptor or the donor component of the bulk heterojunction. He described a process based on a thermo-cleavable polythiophene that produced a completely insoluble and thermally stable polymer-donor template, consisting of neat polythiophene. Although such thermo-cleavable polymers are compatible with roll-to-roll production methods, the use of this technique for fabricating working devices and modules will need to be demonstrated before organic photovoltaics are considered commercially viable.

Paul Blom (University of Groningen, The Netherlands), addressed the important issue of how the transport of free electrons in conjugated polymers compares to that of a free hole — the electron's positive counterpart. He discussed the controlled p-type and n-type doping of poly[2-methoxy-5-(2-ethylhexyloxy)-1,4-phenylenevinylene] (MEH-PPV) deposited from solution, with tetrafluorotetracyanoquinodimethane (F4-TCNQ) and bis(pentamethylcyclopentadienyl) cobalt(II) (DMCO) as p- and n-type dopants, respectively. He demonstrated that by choosing suitable dopant solvents and adjusting the polarity of the solution, aggregation can be prevented and doped films can be deposited with a controlled carrier density. For both, p- and n-type doping greatly improved charge transport, and Blom showed that in MEH-PPV the free-electron mobility is equal to the hole mobility.

Considering the breadth of topics and advances presented at ECME 2009, it is clear that the field of organic semiconductors has witnessed significant progress. Nevertheless, increased fundamental understanding on all length scales — from molecular and supramolecular to micro- and macroscopic dimensions — is critical for realising the full potential that organic semiconductors offer. This will require strong integration of many disciplines. ❐

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MATERIAL WITNESS

SHAKING HANDS WITH ROBOTS

PHILIP BALL

Should robots pretend to be human? The plots of many science-fiction novels and movies — most famously, Philip K. Dick's *Do Androids Dream of Electric Sheep?*, filmed by Ridley Scott as *Blade Runner* — hinge on the consequences of that deception. *Blade Runner* opens with a 'replicant' undergoing the 'Voight-Kampff' test, in which physiological functions betray human-like emotional responses to a series of questions. This is a version of the test proposed by Alan Turing in a seminal 1950 paper pondering the question of whether machines can think[1].

But human-like thought (or its appearances) is only one aspect of the issue of robotic deception. There would be no need to test *Blade Runner*'s replicants if they had been made of gleaming chrome, or showed the jerky motions of a puppet or the stilted diction of an old-fashioned voice synthesizer. To seem truly human, a robot has to perform accurate mimesis on many (perhaps too many) fronts[2].

Today we might insist on a conceptual distinction between such mimicry and the real thing. But this was precisely what Turing set out to challenge in the realm of mind: if you can't make the distinction empirically, in what sense can you say it exists? And in former times, that applied also to the other characteristics of humanoid machines. In the Cartesian world of the eighteenth century, when many considered humans to be merely elaborate mechanisms, it was not clear that the intricate automata that entertained salon society by writing and playing music and games were rigidly demarcated from humanity. Descartes himself denied any such boundary, implying that automata were in a limited sense alive. In his *Discourse on Method* (1637) he even proposed a primitive version of the Turing test, based on the ability to use language and adapt behaviour to circumstance.

One of the most famous automata of that age was a mechanical flute player made by the virtuoso French engineer Jacques de Vaucanson, who unveiled it to wide acclaim in 1738. Not only did it sound right, but its breathing mimicked human mechanics, and its right arm was upholstered with real skin[3]. This feat is brought to mind by a preprint by John-John Cabibihan at the National University of Singapore and colleagues, in which the mechanical properties of candidate 'robot skin' polymers (silicone and polyurethane) are tested for their likeness to human skin[4]. Can we make a robot hand 'feel' human, the researchers ask? Not yet, at least with these materials, they conclude — in the process showing what a delicate task that is (a part of the feel of human skin, for example, comes from its hysteretic response to touch).

Underlying the research is the notion that people will be socially more at ease interacting with robots that seem 'believable' — we will feel queasy shaking hands if the touch is wrong. That's supported by experience[5], but also in itself raises challenging questions about the proper limits of such illusion[6]. Arguably there are times when we should maintain an evident boundary between robot and person. ❐

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