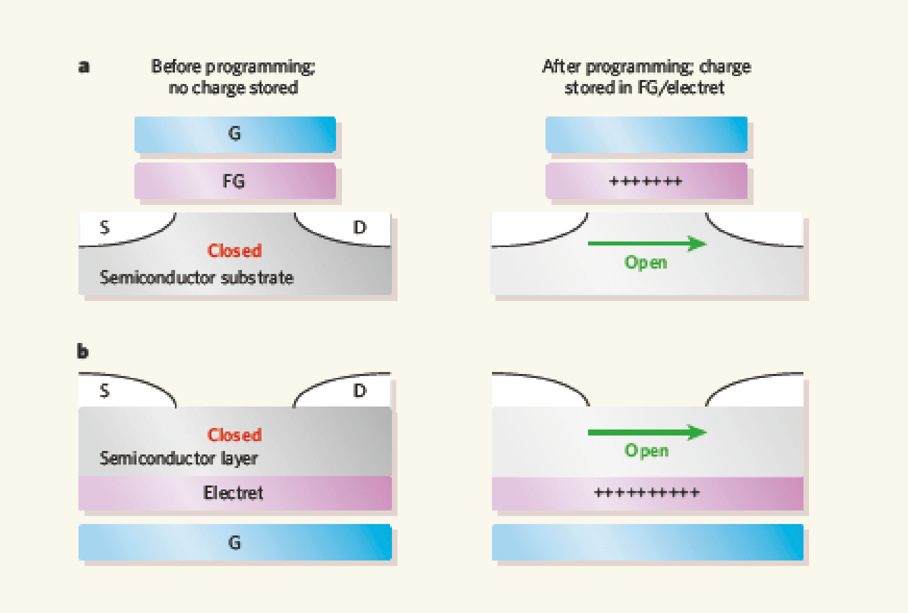

Figure 1 | Methods against memory loss. The basic transistor is a device in which a small voltage applied at the control gate (G) modulates a much larger current flow from source (S) to drain (D) through a semiconductor substrate. **a**, In flash memories, an amount of charge is trapped on a floating gate (FG) that modifies the control voltage required for current to flow from S to D. Whether current flows or not defines a boolean '1' or '0'. The memory of this state persists as long as the charge remains trapped on the floating gate. **b**, In Baeg and colleagues' organic device[1], the same principle is used, but the charge is trapped locally on a thin 'electret' of chargeable polymer, rather than on an isolated floating gate.

current level flowing through the transistor can be used to define boolean '0' and '1' memory states. The charge trapped on the floating gate persists long after all voltages are removed: the information is thus retained after power shutdown, and the transistor functions as a non-volatile memory device.

The non-volatile memory technology developed by Baeg *et al.*[1] takes a slightly different approach (Fig. 1b). Instead of charge being trapped on a floating gate, it is trapped locally on a thin layer of a chargeable polymer. This 'electret' is inserted between the insulating material (silicon dioxide) that makes up the gate and the organic semiconductor (which is pentacene, $C_{22}H_{14}$). When a high-voltage pulse is applied to this electret, it charges up. Applying a reverse voltage pulse either decharges it, restoring the initial state, or charges it to the opposite polarity. The trapped charge imposes an added voltage on the threshold gate voltage, as a floating gate does in a flash memory. This too can be sensed and translated into '1's and '0's, reproducing the stored data, by measuring the current flowing through the transistor.

Memory based on such organic field-effect transistors (OFETs) has been investigated before[3,4], but Baeg *et al.*[1] are the first to report programming speeds of around 1 microsecond — a million times faster than the previous best time of around a second. That marks a decisive step towards making organic memory technology fit for technological purposes.

The new speed record is the result of fast and efficient charge transfer from the organic semiconductor into the polymer electret by means of the electric gate field. The gate field lowers the energy barrier at the interface of the semiconductor and the electret, and so facilitates charge transfer. Once transferred, most of the charge is trapped deeply in the electret. This model explains Baeg and colleagues' most important observations: a critical gate field, caused by the energy barrier, for transfer and trapping of the charges; the lowering of this critical field when the device is illuminated with visible light; a long retention time of the order of hours in the dark; and a decrease of the retention time upon illumination.

These observations also indicate moot points. Can these devices reach data retention times necessary for practical applications — typically years for non-volatile memory? Furthermore, can the device be scaled down to more practical voltages — to 10 V from the 100 V used in the present work — without sacrificing device speed and stability? Such questions remain unanswered, but these encouraging results will without doubt spur intensive investigations into this approach.

The relevance of these results could also go beyond the scope of just memory. Baeg and colleagues[1] aim to produce non-volatile memories that exploit charge trapping and storage, but others are concerned with the converse problem: eliminating charge trapping as much as possible where it gives rise to undesired shifts in threshold voltages that can suppress 'n-channel' (electron) mobility[5] in OFETs, and limit the operational lifetime of 'p-type' (electron-hole-based) logic circuitry[6]. Whatever the intent, all will benefit from a thorough understanding of

50 & 100 YEARS AGO

50 YEARS AGO

Sir Charles Darwin writes: "The first estimate of Avogadro's number is due to Maxwell himself", and expresses his astonishment that Maxwell "should have published a fact of such tremendous importance in a manner that cannot have drawn much attention to it"... The reason for Maxwell's choice seems to have been that he did not claim to communicate anything fundamentally new, but only to discuss a line of reasoning which Loschmidt had published eight years earlier in the *Proceedings* of the Vienna Academy... It is somewhat surprising that Loschmidt's brilliant achievement has been overlooked so frequently, in spite of Maxwell's full acknowledgement... Avogadro did not even know the order of magnitude of this figure approximately; he died nine years before Loschmidt's paper appeared. F. A. Paneth

I must plead guilty to the charge of not having made a very deep search of the older literature in connexion with the evaluation of 'Avogadro's Number'... I am grateful to Prof. Paneth for putting this matter right. C. G. Darwin

From *Nature* 19 January 1957.

100 YEARS AGO

The Future in America — a Search after Realities. By H. G. Wells — There has always been in America a wide-spread contempt, not for the law, but for abstract justice, so that even well-minded, influential people do not set themselves to remedy obvious wrong when by doing so they might hurt themselves or their party in the eyes of multitudes of base and busy, greedy and childish, malevolent and ignorant voters. The unfairness of the southerner to the negro is no longer confined to the south, and the crimes of a few negroes exasperate white people so much that they forget the kindly ways of the average man of colour, and thus the negro question is becoming more complex.

From *Nature* 17 January 1907.