[0019] FIG. 3, shows the switching behavior of a gold/octanethiol/silver junction.

[0020] FIG. 4, is a graphical representation of a semilog plot of measured current as a function of time as the device of the invention is switched from the ON state to the OFF state.

[0021] FIG. 5, is an schematic representation of the incorporation of the silver switch of the invention into a nanoscale crossbar platform.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] Are shown schematically in FIG. 1 two electrodes 10, 12 are separated by a monolayer 14 of an aliphatic or aromatic organic material, which also may contain a functional group, that attaches the monolayer to the electrode.

[0023] In FIG. 1A is shown a schematic representation of the switch in the OFF condition wherein one electrode is metallic silver and the surface of the other electrode, or other electrode 12, may be selected from any electrically conducting substance, such as metals e.g., gold or platinum, or even a composite in which a non-conducting core is covered with a surface covering of a conductive metal e.g., gold or platinum.

[0024] In FIG. 1B is shown the switch in the OFF position even though the voltage bias supplied exceeds the threshold voltage, but only some silver 11 from the silver electrodes becomes ionic, but has not yet bridged the gap between electrodes 10, 12 ($Ag^{O} \rightarrow Ag^{+}$) wherein Ag^{+} is mobile in the electric field.

[0025] FIG. 1C shows the switch in the ON condition in which the voltage bias exceeds the threshold voltage and the silver ions 11 have bridged the gap between electrodes.

[0026] Referring now to FIG. 2 which shows the current-voltage response, the device begins in the OFF state with the bias of +1.0 V applied to the silver electrodes. At position 1 the device remains in OFF state as voltage is swept negative. At a threshold bias, shown at 2, the device switches into the ON state and the device remains in ON state as voltage is swept toward positive values as shown in 3. As shown at 4, at a threshold bias level, the device turns OFF.

[0027] As shown in FIG. 3 which is the actual switching behavior of a Au/octanethiol/Ag junction with the current measured as voltage pulses of −0.5 V (write), −0.1 V (read), and 0.1 V (erase) are applied. One measurement cycle consists of writing, reading, erasing, and reading. The current response shown in the top portion of the figure is consistent with the device turning ON when the write voltage is applied, and OFF when the erase voltage is applied.

[0028] In FIG. 4, is shown a semilog plot of measured current as function of time as the device is switched from the ON state to the OFF state. The decay constant as determined by the slope of the line is directly related to the silver ion propagation velocity and to the maximum switching rate. For octanethiol monolayer (8 carbon atoms), the maximum, switching voltage is 13 kHz, whereas octadecanethiol monolayer (18 carbon atoms), the maximum switching rate is 2 kHz.

[0029] The self-assembled monolayer switching device of the present invention is comprised of three components: a silver electrode 10, a self-assembled monolayer 11, and a second electrode 12 which can be of any metal or any other electrically conductive surface.

[0030] The device geometry can be either be a self-assembled monolayer grown on a silver surface, with a counter electrode place into contact with the monolayer, or a self-assembled monolayer on a different electrically conductive surfaces, e.g., metal surface, with a silver electrode placed into contact.

[0031] The composition of the monolayer can be satisfied by aliphatic or aromatic organic materials which have sufficiently low electrical conductivity as to be considered non-conductive, and must permit the flow of ions, such as silver ions, such as silver ions, to bridge the gap between electrodes 10, 12. Functional groups which can bond to metallic conductors are desirable, but not essential, to the composition of the monolayer.

[0032] The device is in the OFF state until a negative threshold bias is applied to the counter electrode which ionizes the silver electrode and turns the device ON (See FIGS. 1A-1C). The device remains in the ON state until a sufficient positive bias is applied to the counter electrodes.

[0033] The self-assembled monolayer may be aliphatic or aromatic, and may contain any functional group that attaches it to the metal surface. The maximum switching rate can be controlled by choice of self-assembled monolayer. Longer molecules results in slower switching rates, but more robust junctions as shown in FIG. 3.

[0034] To fabricate the silver self-assembled monolayer switch, all that is required is formation of a self-assembled monolayer on a silver surface, followed by contacting that monolayer using a second electrode or alternatively contacting the self-assembled monolayer on a metallic conducting surface and contacting it with the silver surface of the electrode.

COMMERCIAL APPLICATIONS

[0035] The self-assembled monolayer silver switch operates on the nanoscale and requires little effort to fabricate. It therefore has the potential to outperform conventional silicon devices, either in terms of size or cost. Its most probable uses are as a low-cost memory element or logic element. It could also function as a nanofuse. One such use is the fabrication of a nanoscale crossbar array as shown in FIG. 5 which addressed a large number of discrete metal-molecule-metal junctions in an overall small footprint, which provides a pathway to programmable logic and addressable memory in a molecular junction. It should be possible to incorporate the self-assembled monolayer silver switch into the array as shown in FIG. 5.

[0036] In a most particularly preferred embodiment the electrode is silver while the other electrically conductor is gold or a gold covered core surface. Other conductors can be used such as platinum, or other conductive metals.

[0037] Although, we have described the invention in connection with certain preferred embodiments, it is to be expressly understood that our invention is not limited by the preferred embodiments or examples, but rather that those