SELF-ASSEMBLED MONOLAYER BASED SILVER SWITCHES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit under 35 U.S.C. 119 of U.S. Provisional Application Ser. No. 60/845,598 filed Sep. 19, 2006, the entire disclosure of which are hereby incorporated by reference its entirety.

TECHNICAL FIELD

[0002] The present application is directed to a switching device based upon two electrodes separated by a self-assembled monolayer. In a most preferred environment one of the electrodes must be composed of silver and the other is any electrically conductive material, such as metals, carbon or graphite, or a composite material, such as a non-conducting core coated with a conductive element e.g. metal. In a high-resistance OFF state, the two electrodes are separated by the organic monolayer. Application of a negative threshold bias causes a silver ion filament to bridge the gap between the two electrodes, changing the device into a low-resistance ON state. The device may be turned OFF by application of a positive threshold bias, which causes the ionic filament to retract back into the silver electrode. Such switches are best suited for use in memory or logic applications and are smaller in device area than the current technology standard. When fabricated in bulk, these switches provide a cost-effective alternative to traditional silicon devices.

BACKGROUND ART

[0003] U.S. Patent Publications 20050127524 entitled "Solid Electrolyte Switching Device" and 20040089882 entitled "Electronic Device Having Controllable Conductance" have emanated from the same research group as the present invention.

[0004] These two applications describes switches formed using a solid electrolyte layer that is both an ionic and electronic conductor. Examples are silver sulfide or silver selenide. A silver sulfide layer is mobile in an electronic field, and devices switched between ON and OFF states when the sulfide layer switches between bridging the gap between electrodes and not bridging that gap.

[0005] The present device differs from those described in these publications in several ways. The device does not require a mixed ionic/electronic conductor; the device of the invention uses a self-assembled monolayer to define the spacing between two electrodes; the switching speed in the inventive devices is controlled by the identity of the self-assembled monolayer and, the claimed device does not require the presence of sulfur.

[0006] Furthermore it is much more difficult to fabricate the devices described in these publications than it is to fabricate the devices of the present invention.

[0007] To fabricate the devices of the publications requires "a substrate in which surface is coated with an insulation layer; a first interconnection layer set on said substrate; an ion supplying layer set on said first interconnection layer; a solid electrolyte layer set on said ion supplying layer, an interlevel insulating layer having a via hole set to cover said first interconnection layer, said ion supplying layer, and said solid electrolyte; a counter electrode layer set to contact said solid electrolyte layer through said via hole of said interlevel insulating layer, and a second interconnection layer set to cover said counter electrode layer." See, U.S. Patent Publication 20050127524.

[0008] 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 electric conducting electrode.

SUMMARY OF INVENTION

[0009] It is an object of the present invention to provide a device capable of OFF electric conduction i.e. a switch which is small in size, Is easy to fabricate, does not require a large number of fabrication steps and uses readily available materials to fabricate the device.

[0010] It is a further object of the invention to provide a method of manufacture of such devices.

[0011] It is a further object of the invention to provide a plurality of such devices in a matrix or array for use in logic circuits.

[0012] These and other objects can be achieved by the employment of at least two electrically conductive electrodes separated by a self-assembled monolayer. In a most preferred embodiment, at least one of the electrodes must be composed of silver and other electrode can be any electrically conducting material e.g., a metal, carbon or graphite, or a composite, such as a non-conducting core covered with a metallic or electrically conductive coating. An organic monolayer can be deposited on one of the conductors e.g., on a silver conductor and the other electrode placed in contact with the monolayer so as to complete the structure. Application of a negative threshold bias will cause a silver ion filament to bridge the gap between the two electrodes changing the device into a low-resistance ON state. The device may be turned OFF by application of a positive threshold bias which cause the ionic filament to retract back into the silver electrode.

[0013] The achievement of these and other objects will become apparent with reference to the following detailed description of the preferred embodiments and with reference to the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] FIG. 1, is a schematic representation of a simple form of the device of the present invention.

[0015] FIG. 1A, is a schematic representation wherein the switch is OFF when the voltage applied is less than the threshold voltage.

[0016] FIG. 1B, shows the switch OFF when the voltage applies is greater than the threshold voltage but the bridge between the conductors has not yet fully formed; and,

[0017] FIG. 1C, shows the switch in the ON position when the voltage is greater than the threshold voltage, but that the silver ions have bridged the gap between the two electrical conductors;

[0018] FIG. 2, is a graphical representation of a current-voltage response of the device shown in FIG. 1.