CONDUCTIVE STRUCTURES

TECHNICAL FIELD

This invention relates to conductive structures used in electric variable resistance devices to provide changes in electrical resistance with movement and changes in pressure. The structures can also provide electrical isolation and shielding and allow a start resistance to be set. Further, they can provide a leakage path for electrostatic voltages, add a degree of movement and tactility to operation and in preferred forms can respond to the presence of chemical, biological or radioactive species.

BACKGROUND ART

Reference is made to prior applications: A: PCT/GB98/00206, published as WO 98/33193; and B: PCT/GB99/00205, published as WO 99/38173, which disclose polymer compositions having the electrical property of insulation when quiescent but conductance when stressed mechanically or in electric fields. Typically, in a high resistance state (typically 10^{12} ohm. cm), they change to a low resistance state (typically milliohm. cm) by the application of such stress. It appears that the effective resistance of the polymer component phase is reduced owing to electron-tunnelling and carrier trapping. When in such a state, the polymer composition is able to carry high electric current densities, even though there are no complete metallic pathways, i.e. the composition is below the percolation threshold. The disclosure of these prior applications is incorporated herein by reference and extracts therefrom are quoted hereinbelow. The invention may use materials described therein but is not limited thereto.

SUMMARY OF THE INVENTION

According to the invention in its first aspect an electric variable resistor comprises externally connectable electrodes bridged by an element containing polymer and particles of metal, alloy or reduced metal oxide, said element having a first level of conductance when quiescent and being convertible to a second level of conductance by change of stress applied by stretching or compression or electric field, characterised by comprising means to stress the element over a cross-sectional area proportional to the level of conductance required.

In this specification:

the term 'variable resistor' may include a switch, because the range of resistance available may amount to open circuit; and

the particles of metal, alloy and reduced metal oxide, whether encapsulated by polymer or not, and whether stressed or stressable to conductance, will be referred to as 'strongly conductive';

The stressing means may comprise an actuator having variable geometry at the site of application, for example an oblique shoe or a selectively activatable array of pins or radiation beam sources. A variable resistor preferred for simplicity comprises the element and, matching the cross section thereof, a layer composed of insulating or weakly conductive material and containing interstices accessible to mobile fluid. (Mobile fluid need not in fact be present, e.g. the variable resistor may be operated in a vacuum). More particularly the element may be of a yielding consistency permitting penetration through the layer to an extent depending on an applied compression force. Preferably the element comprises a material that itself increases conductance when compressed.

The layer has a base structure selected suitably from foam, net, gauze, mat or cloth and combinations of two or more of these. The base structure and the material from which it is made affects, and may be chosen to suit, the physical and mechanical limits and performance of the overall structure and also for a moderating influence on the amount of creep normally associated with flexible conductive polymers.

Particularly useful layers comprise one or more of open-cell polymer foam, woven or non-woven textile e.g. felt, possibly with fibre/fibre adhesion, and 3-dimensional aggregations of fibre or strip.

The element may have a base structure of the same general type as the layer, but chosen to suit its particular function in the variable resistor. For example an element of collapsed structure may be used in combination with a non-collapsed layer, as described further below. Preferably the element base structure contains interstices accessible to mobile fluid.

The invention also provides, as a new article, a porous body having a base structure of polymer containing interstices accessible to mobile fluid and containing polymer and particles of metal, alloy or reduced metal oxide, said body having a first level of electrical conductance when quiescent and being convertible to a second level of conductance by change of stress applied by stretching or compression or electric field, characterised in that the base structure is a collapsed foam or cloth. Such a porous body may have at least one of the preferred features set out herein in relation to the variable resistor.

In the variable resistor the stressing means may be effective to for example: (a) apply conductance-increasing stress and/or (b) reverse such stress or act against pre-existing stress.

If the stressing means acts by compression or stretching, it may be for_example mechanical, magnetic, piezoelectric, pneumatic and/or hydraulic. Such application of stress can be direct or by remote control. If compressive, it may expel mobile fluid from the interstices of the element and/or layer. In a simple switch the fluid is air and the element and/or layer will be open to atmosphere. Whether mobile fluid is present or not, the element and/or layer may be resilient enough to recover fully alone or aided by a resilient operating member such as a spring. For reversing mechanical stress the element and layer may be set up in a closed system including means to force the mobile fluid into the interstices. Such a system may provide a means of detecting movement of a workpiece acting on the fluid outside the variable resistor.

The mobile fluid may be elastic, for example a non-reactive gas such as air, nitrogen or noble gas or possibly a readily condensable gas. Alternatively the fluid may be inelastic, for example water, aqueous solution, polar organic liquid such as alcohol or ether, non-polar organic liquid such as hydrocarbon, or liquid polymer such as silicone oil. In an important case the fluid is a test specimen to which the conductance of the variable resistor is sensitive.

Among the materials suitable for making the element and layer are:

for net, gauze, mat or cloth:

hydrophobic polymers such as polyethylene, polyalkyleneterephthalate, polypropylene, polytetrafluoroethylene, polyacrylonitrile, highly esterified and/or etherified cellulose, silicone, nylons; and

hydrophilic polymers such as cellulose (natural or regenerated, possibly lightly esterified or etherified), wool and silk;