REDUCED CERAMIC HEATING ELEMENT

The present invention relates to an electrical heating element. More particularly, the invention relates to a heating element for heating an aerosol-forming substrate in an electrically heated aerosol-generating system. The present invention relates to a method of manufacturing a heating element, and to a method for manufacturing a heating element for heating an aerosol forming substrate in an electrically heated aerosol-generating system. The invention finds particular application as a heating element for heating an aerosol-forming substrate in an electrically operated smoking system and as a method for manufacturing a heating element for heating an aerosol forming substrate in an electrically operated smoking system.

Prior art documents, such as EP-A-0917830, describe heating elements for electrically heating tobacco products that consist of a plurality of discrete metallic heating elements running axially along the length of the smoking device, and spaced around its circumference. The heating elements are necessarily complex and expensive to manufacture as they require a number of metal forming steps.

Internal heating elements have also been proposed, which are inserted directly into the tobacco products. This provides for improved efficiency, as all heat energy is transferred to the sensorial media and it also allows for a reduction in the size of the smoking system, and in particular its diameter as there is less need for thermally insulating cladding.

The inventors have appreciated that it would be advantageous to provide a heating element suitable for use as an internal heating element in an electrically operated smoking system that is simple and inexpensive to manufacture and a manufacturing method for such a heating element that provides for flexibility in the heating element design.

According to a first aspect of the invention, there is provided an electrical heating element including a main body having a ceramic material and an electrically conductive path formed on or in the main body, the electrically conductive path having a reduced form of a portion of the ceramic material of the main body and having first and second contact portions for connection to a voltage source, wherein the main body is formed in a manner to receive an aerosol-forming substrate, and wherein the electrically conductive path forms a pattern on a surface of the main body.

Also disclosed is an electrical heating element comprising a main body comprising a ceramic material and an electrically conductive path formed on or in the main body, the electrically conductive path comprising a reduced form of the ceramic material and having first and second contact portions for connection to a voltage source, wherein the main body is formed in a manner to receive an aerosol-forming substrate.

The electrically conductive path may be formed, for example, by placing the main body in a reducing environment at a sufficient temperature for a predetermined duration. Alternatively, the electrically conductive path may be formed using an electro-chemical reduction process. In either case the electrically conductive path is preferably formed as a conductive layer on a surface of the main body. Preferably, the depth of the conductive layer is less than 10μm. The depth of the conductive layer can be selected by selecting the conditions under which it is formed, such as the temperature and duration of treatment. The extent to which it covers the main body may also be

altered by selectively etching portions of the conductive path or by masking portions of the main body during the reduction process. In this way a desired resistance for the heating element can be obtained. In a preferred embodiment the resistance of the heating element is between 0.5 and 2 Ohms.

The main body may be formed fully or partially from a metal oxide and the conductive layer formed from the metal component of the metal oxide. For example, the main body may be formed from Zirconia and the conductive path formed from Zirconium. Alternatively, the main body may be formed of Alumina and the conductive path formed from Aluminium.

The electrically conductive path can perform as a resistive heater and can be provided on the main body in a many ways, allowing for great design flexibility.

The main body may be formed by injection moulding and sintering. The shape and size of the main body may be chosen to suit a particular application.

The electrically conductive path may completely cover a surface of the main body. As mentioned in the first aspect~~Alternatively~~, the electrically conductive path ~~may~~ forms a pattern on a surface of the main body. The pattern may define a plurality of electrically conductive pathways between the first and second contact portions.

The main body preferably has an elongate form with the first and second contact portions positioned at a first end of the main body and the electrically conductive path extending to and from a second end of the main body.

The main body may be formed in other shapes, such as in tubular form or in a planar form. The present invention allows for the use of complex shapes for the heating element that would be problematic when using a plating or deposition technique for forming a conductive layer.

Preferably, the main body has a substantially circular cross-section. This is beneficial because it allows for easy insertion in and removal from an aerosol forming substrate.

The main body may be covered with a passivation layer, such as glass. This increases the stability of the conducting path.

According to a second aspect of the invention, there is provided an electrically heated aerosol generating system for receiving an aerosol forming substrate comprising one or more heating elements in accordance with the first aspect of the invention and a voltage source coupled to the heating elements at the first and second contact portions.

According to a third aspect of the invention, there is provided a method of manufacturing an electrical heating element, said method including the steps of: forming a heating element main body, the main body including a ceramic material formed in a manner to receive an aerosol-forming substrate; placing the heating element main body in a reducing environment at sufficient temperature to form a conductive path on the main body, the conductive path including a reduced form of the ceramic material and forming a pattern on a surface of the main body, wherein the pattern is formed by selectively etching portions of the conductive path or by masking portions of the main body while it is in the reducing environment; and providing electrical contact portions for connection of the conductive path to a voltage source.

Also disclosed is a method of manufacturing an electrical heating element, comprising the steps of: forming a heating element main body, the main body comprising a ceramic material formed in a manner to receive an aerosol-forming substrate; placing the heating element main body in a reducing environment at sufficient temperature to form a conductive path on or in the main body, the conductive path comprising a reduced form of the

ceramic material; and providing electrical contact portions for connection of the conductive path to a voltage source.

Preferably, the step of forming the heating element main body comprises injection moulding. Alternatively, the step of forming the heating element main body may comprise hot isostatic pressing, slip casting or dry pressing. The step of forming the heating element main body may further include machining. The step of forming the heating element main body may further comprise firing or sintering.

The reducing environment is preferably substantially free of oxygen. The step of placing the heating element main body in a reducing environment may comprise placing the main body in a hydrogen environment or a carbon monoxide environment. Preferably, the hydrogen environment comprises a flow of hydrogen gas. The temperature that is sufficient to form a conductive layer on the surface of the main body is dependent on the atmosphere and on the material composition of the main body. However, preferably the sufficient temperature is greater than 200 °C. More preferably, the sufficient temperature is between 1000 °C and 1300 °C. Preferably, the step of placing the heating element main body in a reducing environment comprises placing the heating element main body in a reducing environment for at least one hour and more preferably for at least two hours.

Preferably, the method further comprises forming a passivation layer on the heating element main body subsequent to the step of placing the heating element main body in a reducing environment. The passivation layer prevents, or substantially reduces, re-oxidation of the conductive path. The passivation layer may be formed from glass using a chemical vapour deposition or plasma phase deposition technique.

According to a fourth aspect of the invention, there is provided a method of manufacturing an electrical heating element, said method including the steps of: forming a heating element main body, the main body including a ceramic material formed in a manner to receive an aerosol-forming substrate; placing the heating element main body in a reducing electrolyte and performing an electro-chemical reduction of the heating element main body to form a conductive path on the main body, the conductive path comprising a reduced form of the ceramic material and forming a pattern on the surface of the main body, wherein the pattern is formed by selectively etching portions of the conductive path or by masking portions of the main body while it is in the reducing electrolyte; and providing electrical contact portions for connection of the conductive path to a voltage source.

Also disclosed is a method of manufacturing an electrical heating element, comprising the steps of: forming a heating element main body, the main body comprising a ceramic material formed in a manner to receive an aerosol-forming substrate; placing the heating element main body in a reducing electrolyte and performing an electro-chemical reduction of the heating element main body to form a conductive path on or in the main body, the conductive path comprising a reduced form of the ceramic material; and providing electrical contact portions for connection of the conductive path to a voltage source.

The reducing electrolyte may be calcium chloride.

An embodiment of the invention will be further described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1a is an illustration of a heating element in accordance with an embodiment of the invention;

Figure 1b is a schematic illustration of a cross section of the heating element of Figure 1a;

CLAIMS:

1. An electrical heating element comprising a main body comprising a ceramic material and an electrically conductive path formed on or in the main body, the electrically conductive path comprising a reduced form of the ceramic material and having first and second contact portions for connection to a voltage source, wherein the electrically conductive path forms a pattern on a surface of the main body.

2. An electrical heating element according to claim 1, wherein the main body is formed fully or partially from a metal oxide and the conductive path is formed from the metal component of the metal oxide.

3. An electrical heating element according to claim 1 or claim 2, wherein the main body is formed from Zirconia and the conductive layer formed from Zirconium.

4. An electrical heating element according to any preceding claim, wherein the main body has a substantially circular cross-section.

5. An electrical heating element according to any preceding claim, wherein the main body has an elongate form with the first and second contact portions positioned at a first end of the main body and the electrically conductive path extending to and from the second end of the main body.

6. An electrical heating element according to any preceding claim, further comprising a passivation layer on an external surface of the main body.

7. An electrically heated aerosol generating system for receiving an aerosol forming substrate comprising one or more heating elements in accordance with any preceding claim and a voltage source coupled to the heating elements at the first and second contact portions.

8. A method of manufacturing an electrical heating element, comprising the steps of:
forming a heating element main body, the main body comprising a ceramic material;

placing the heating element main body in a reducing environment at sufficient temperature to form a conductive path on the main body, the conductive path comprising a reduced form of the ceramic material and forming a pattern on a surface of the main body; and

providing electrical contact portions for connection of the conductive path to a voltage source.

9. A method according to claim 8, wherein the step of placing the heating element main body in a reducing environment comprises placing the main body in a hydrogen environment.

10. A method according to claim 8 or 9, wherein the sufficient temperature is between 1000 °C and 1300 °C.

11. A method according to claim 8, 9 or 10, further comprising the step of forming a passivation layer on the heating element main body subsequent to the step of placing the heating element main body in a reducing environment.

12. A method according to any one of claims 8 to 11, wherein the step of forming the heating element main body comprises injection moulding.

13. A method of manufacturing an electrical heating element, comprising the steps of:

forming a heating element main body, the main body comprising a ceramic material;

placing the heating element main body in a reducing electrolyte and performing an electro-chemical reduction of the heating element main body to form a conductive path on the main body, the conductive path comprising a reduced form of the ceramic material and forming a pattern on the surface of the main body; and

providing electrical contact portions for connection of the conductive path to a voltage source.

Claims:

1. An electrical heating element including a main body having a ceramic material and an electrically conductive path formed on or in the main body, the electrically conductive path having a reduced form of a portion of the ceramic material of the main body and having first and second contact portions for connection to a voltage source, wherein the main body is formed in a manner to receive an aerosol-forming substrate, and wherein the electrically conductive path forms a pattern on a surface of the main body.

2. An electrical heating element according to claim 1, wherein the main body is formed fully or partially from a metal oxide and the conductive path is formed from the metal component of the metal oxide.

3. An electrical heating element according to claim 1 or claim 2, wherein the main body is formed from Zirconia and the conductive layer formed from Zirconium.

4. An electrical heating element according to any preceding claim, wherein the main body has a circular or substantially circular cross-section.

5. An electrical heating element according to any preceding claim, wherein the main body has an elongate form with the first and second contact portions positioned at a first end of the main body and the electrically conductive path extending to and from the second end of the main body.

6. An electrical heating element according to any preceding claim, further including a passivation layer on an external surface of the main body.

7. An electrically heated aerosol generating system for receiving an aerosol forming substrate including one or more heating elements in accordance with any preceding claim and a voltage source coupled to the heating elements at the first and second contact portions.

8. A method of manufacturing an electrical heating element, said method including the steps of:

forming a heating element main body, the main body including a ceramic material formed in a manner to receive an aerosol-forming substrate;

placing the heating element main body in a reducing environment at sufficient temperature to form a conductive path on the main body, the conductive path including a reduced form of the ceramic material and forming a pattern on a surface of the main body, wherein the pattern is formed by selectively etching portions of the conductive path or by masking portions of the main body while it is in the reducing environment; and

providing electrical contact portions for connection of the conductive path to a voltage source.

9. A method according to claim 8, wherein the step of placing the heating element main body in a reducing environment includes placing the main body in a hydrogen environment.

10. A method according to claim 8 or 9, wherein the sufficient temperature is between 1000 °C and 1300 °C.

11. A method according to claim 8, 9 or 10, further including the step of forming a passivation layer on the heating element main body subsequent to the step of placing the heating element main body in a reducing environment.

12. A method according to any one of claims 8 to 11, wherein the step of forming the heating element main body includes injection moulding.

13. A method of manufacturing an electrical heating element, said method including the steps of:

forming a heating element main body, the main body including a ceramic material formed in a manner to receive an aerosol-forming substrate;

placing the heating element main body in a reducing electrolyte and performing an electro-chemical reduction of the heating element main body to form a conductive path on the main body, the conductive path comprising a reduced form of the ceramic material and forming a pattern on the surface of the main body, wherein the pattern is formed by selectively etching portions of the conductive path or by masking portions of the main body while it is in the reducing electrolyte; and

providing electrical contact portions for connection of the conductive path to a voltage source.