

Method for producing electric trigger elements for pyrotechnic articles

The invention relates to a method for producing electric trigger elements for pyrotechnic articles such as fuses or igniters.

Electric trigger elements serve to initiate a primary explosive as the first member of a fuse or igniter chain. For this purpose, the heat generated which is emitted by a resistor through which a current flows is used. The primary explosive is in direct contact with the electric resistor and is initiated by reaching its deflagration temperature. The electric resistor can be configured, for example, in the form of a wire.

The production method relates to a special form of igniter element wherein the electric resistor is formed by a thin metal film on an insulating substrate surface. Trigger elements of this type have been in general use for many years. The resistor layer made of a metal with a high specific resistance is applied by a physical vapor deposition (PVD) process onto the substrate (e.g. ceramic or glass) and, if required, is reinforced remote from the well-defined resistor area by a further layer of a material with a high electrical conductivity. The geometry of the resistor area is adapted to the requirements of the use, in particular, in relation to the resistance value and the initiation characteristic (e.g. the required current strength). In established production methods, the form of the resistor area (the thickness of which is given by the layer thickness of the metal film) is generated by laser material machining on each individual component.

Due to the influence of the high laser power during the material machining, undesirable material changes can occur at the edges of the laser cut. These material changes (of both geometrical and substantial types) have negative effects on the initiation characteristics of the resistor layer. Additionally, the individual machining of each trigger element is very time-consuming.

It is an object of the invention to provide a new method for producing initial elements based on PVD layers that enables a clean configuration of the edges of the resistor layers. It is also desirable to reduce the manufacturing costs.

According to the invention, the object is achieved in that firstly a lacquer is applied by photolithography onto the substrate. This prevents a coating of the substrate in a large region, but leaves free a region of the substrate surface of precisely defined width.

Subsequently, the PVD process is carried out on the lacquer and the substrate. By this means, an electrically conductive layer is produced between the two terminal poles of the trigger element. The lacquer is subsequently released from the substrate so that electrically non-conductive substrate and a resistor region of precisely defined width is obtained, through which the current can later flow from one terminal pole to the other. The thickness of the resistor layer is already set during the PVD process. In order to generate the length equally precisely, a photolithographic process is again carried out and a precisely defined region of the resistor strip is covered with lacquer. Subsequently, the entire substrate surface is covered with a relatively thick layer of readily conductive metal (e.g. by galvanic gilding). The application of the metal is configured so that in regions which have a bare substrate from the first photolithographic process, no metal adheres. Subsequently, the lacquer from the second photolithographic process is again removed. Due to the photoresist, a precisely defined region remains, which is formed only by the layer of metal with a high specific resistance. The first photolithographic process defines the width of the resistor layer and provides for insulation in the surrounding regions, the second process defines the length and the second layer provides for good electrical conductivity and good contact at the terminal poles. The PVD process itself defines the thickness of the resistor layer. For precise setting of the electric resistance, the PVD layer can originally be configured too thick and the thickness can be reduced by step-wise removal and thus the resistance can be set precisely.

If no reinforcement of the contact areas by additional readily conductive layers is required--the entire resistance geometry can be realized with a suitable photomask in a single lithographic process.

The invention relates to:

- a method for producing electric trigger elements for pyrotechnic articles, wherein in a first stage
 - a) a lacquer is applied by photolithography to an electrically non-conductive substrate,
 - b) a conductive material having a specific resistance of $0.1 \Omega \cdot \text{mm}$ to $5.0 \Omega \cdot \text{mm}$ is applied to the lacquer and substrate by means of a PVD process in a layer thickness of $0.02 \mu\text{m}$ to $8.0 \mu\text{m}$, and
 - c) the lacquer is removed from the substrateand possibly, in a second stage,
 - d) a photolithographic process is again carried out in which a precisely

defined region of the resistor strip is covered with photoresist,

- e) the entire substrate surface is covered with a layer of a metal having a specific resistance of $0.01 \Omega \cdot \text{mm}$ to $0.1 \Omega \cdot \text{mm}$ in a thickness of $0.1 \mu\text{m}$ to $20 \mu\text{m}$, wherein the application of the metal is configured such that in regions which have a bare substrate from the first photolithographic process, no metal adheres, and
 - f) the lacquer from the second photolithographic process is again removed;
- a method in which, in the first stage, the width of the resistor layer is defined by the photolithographic process and insulation is provided in the surrounding regions;
 - a method in which, in the second stage, the length of the resistor layer is defined by the photolithographic process;
 - a method in which a conductive material having a specific resistance of $0.1 \Omega \cdot \text{mm}$ to $5.0 \Omega \cdot \text{mm}$ is applied by means of the PVD process in a layer thickness of $0.02 \mu\text{m}$ to $8.0 \mu\text{m}$, and in step b) the thickness of the resistor layer is defined;
 - a method in which the layer applied in step b) is applied at a thickness exceeding the desired resistance value and by step-wise removal, the thickness is reduced and thereby the resistance is precisely set;
 - a method in which, in the event that no reinforcement of the contact surfaces by means of additional readily conductive layers is required, the entire resistor geometry is realized with a photomask in a single lithographic process;
 - a method wherein possibly in step e) an electrically readily conductive layer is applied;
 - the use of the method for producing pyrotechnic trigger elements, and thus
 - the photolithographic creation of resistor layers with precisely defined geometry on a non-conductive substrate,
 - the stipulation of the length and width of the resistor layer by using photomasks for specific curing of photoresist, and
 - the use of the production method described for pyrotechnic trigger elements.

The special advantages of this method lie therein that very precisely defined edges of the resistor film come about and the material is homogeneous over the entire resistor area (no material changes due to point-wise heat effects as with laser machining). Furthermore, using photomasks, the resistor can be applied simultaneously for very many trigger elements and the parts must be separated at a later time point in the production process, which makes the process quicker and more economic than conventional methods.

Claims

1. A method for producing electric trigger elements for pyrotechnic articles, characterized in that, in a first stage,
 - a) a lacquer is applied by photolithography to an electrically non-conductive substrate,
 - b) a conductive material having a specific resistance of $0.1 \Omega \cdot \text{mm}$ to $5.0 \Omega \cdot \text{mm}$ is applied to the lacquer and substrate by means of a PVD process in a layer thickness of $0.02 \mu\text{m}$ to $8.0 \mu\text{m}$, and
 - c) the lacquer is removed from the substrateand possibly, in a second stage
 - d) a photolithographic process is again carried out in which a precisely defined region of the resistor strip is covered with photoresist,
 - e) the entire substrate surface is covered with a layer of a metal having a specific resistance of $0.01 \Omega \cdot \text{mm}$ to $0.1 \Omega \cdot \text{mm}$ in a thickness of $0.1 \mu\text{m}$ to $20 \mu\text{m}$, wherein the application of the metal is configured such that in regions which have a bare substrate from the first photolithographic process, no metal adheres, and
 - f) the lacquer from the second photolithographic process is again removed.
2. The method as claimed in claim 1, characterized in that, in the first stage, the width of the resistor layer is defined by the photolithographic process and insulation is provided in the surrounding regions.
3. The method as claimed in claim 1, characterized in that the length of the resistor layer is defined by the photolithographic process in the second stage.
4. The method as claimed in claim 1 or 2, characterized in that the thickness of the resistor layer is determined by the PVD process in step b).
5. The method as claimed in claim 1 to 4, characterized in that the layer applied in step b) is configured in a thickness exceeding the desired resistance value and by step-wise removal, the thickness is reduced and thereby the resistance is precisely set.
6. The method as claimed in claim 1 to 4, characterized in that, in the event that no reinforcement of the contact surfaces by means of additional readily conductive layers is required, the entire resistor geometry is realized with a photomask in a single lithographic process.

7. The method as claimed in claim 1 to 6, characterized in that, in step e), a readily conductive layer is applied.
8. Use of the method as claimed in claim 1 to 7 for producing pyrotechnic trigger elements.