

PROXIMITY SENSOR

The present invention relates to an electronic proximity sensor.

Electronic proximity sensors with electric or electronic circuits that can be influenced capacitively from outside, such as for example oscillators, have been known for a long time (see DE 2744785). Generally speaking, by moving an object close to the surface of the sensor, the capacitance of at least one element of the circuit is changed. This causes changes in the electric behavior of the circuit. For example, in an oscillating circuit, the frequency can be changed. Such a change of frequency can be detected and interpreted as a switching signal.

In particular, the modern automotive industry increasingly makes use of multifunctional surfaces that can also be used as sensor surfaces. The trend in this respect is moving away from classical switches or pushbuttons for controlling functions towards sensor elements that are directly integrated into synthetic surfaces. The latter can, as described by way of example above, detect by means of capacitive evaluation whether a finger is moving closer to the sensor surface and thus whether switching functions must be executed. The relevant technology of sensor query is well known and also technically developed.

The sensor elements in such cases lie below the decorative surfaces and can thus quite easily be integrated for example in the synthetic surfaces of an automobile interior. A considerable problem is however currently that the decorative surfaces over the sensor-active surfaces should mostly have a metallic appearance.

The metallic coating of synthetic surfaces is a known technique that however has the great disadvantage of the metallic coatings in the surface being conductive and thus, under the decorative surface, of capacitive sensing of the signal being no longer possible.

The problem can thus be described as follows: on the one hand, there is a request for synthetic surfaces with a metallic gloss, which on the other hand do not shield the capacitive sensors lying underneath. The nature of the problem poses particular challenges

in that the metallic surfaces are characterized both by their degree of gloss and by their shade of color (CIE lab values).

Embodiments of the present invention seek to overcome or at least alleviate the problem described above.

The decorative surface of a capacitive proximity sensor is coated with a thin semiconductor layer, the thickness of which is preferably between 10nm and 100nm. Silicon is particularly suited for this purpose. This coating can be applied by means of physical vapor deposition (PVD). Tightness, and thus preferred layers, can be achieved by means of a magnetron sputtering process.

According to a first aspect of the present invention, there is provided an electronic proximity sensor comprising: a decorative surface made of a synthetic material; a capacitive sensor element placed below the decorative surface disposed in such a manner that the sensor element can detect by means of capacitive evaluation whether a finger is moving closer to a sensor surface and thus whether switching functions must be executed; wherein the decorative surface is coated with a coating comprising at least one thin layer made of a semiconductor material which provides metallic gloss to the decorative surface and which allows transmission of electromagnetic rays, wherein the coating comprises a primer UV acryl lacquer layer provided as intermediate layer between the decorative surface and the at least one thin layer made of a semiconductor material in order to smooth any potential surface structure, wherein the at least one thin layer made of semiconductor material is a layer made of silicon or germanium or silicon and germanium.

According to a second aspect of the present invention, there is provided a method for producing an electronic proximity sensor, the method comprising the steps of: providing a decorative surface, the decorative surface comprising synthetic material; providing an electronic proximity sensor having a capacitive sensor element placed below the decorative surface, such that the sensor element can detect by means of capacitive evaluation whether a finger is moving closer to a sensor surface and thus whether switching functions must be executed; coating the decorative surface with a primer UV acryl lacquer layer, the primer UV acryl lacquer is configured to smooth any potential surface structure; coating the

decorative surface with a semiconductor layer, such that the semiconductor layer provides metallic gloss to the decorative surface and allows transmission of electromagnetic rays; wherein the semiconductor layer is a layer made of silicon or germanium or silicon and germanium.

Embodiments of the invention will now be described in more detail on the basis of examples.

According to a first embodiment of the present invention, a silicon layer with a thickness of 35nm (i.e. within the 10nm to 100nm thickness range) is deposited as semiconductor layer onto the surface of a capacitive proximity sensor. In order to smooth any potential surface structures, a primer (UV acryl lacquer) is first applied onto the surface. After applying the Si-layer by means of magnetron sputtering, a top layer (UV acryl lacquer) is applied in the present example for additional protection of the thin Si-layer. This results in a bluish to yellowish metallicly shimmering surface. Thanks to the low electric conductivity of silicon, the sensor is not shielded electrically resp. capacitively.

According to a second embodiment of the present invention, the semiconductor layer is executed as a layer system. This can for example be structured as alternating layer system with a semiconductor, e.g. Si and a dielectric, e.g. SiO₂. The total thickness of the Si-layers should in this case again be in the range between 10nm and 100nm. In order to achieve the desired transmission and reflection characteristic in the visible range of the spectrum of electromagnetic rays, performance-enhanced optimization programs for optical thin-films are nowadays available to the one skilled in the art. A more in-depth explanation in this respect is therefore eschewed in the present case.

According to a third embodiment of the present invention, Germanium is used as semiconductor material for the coating. This coating can also be executed as an individual thin monolayer with a thickness of 10nm to 100nm or as an alternating layer system with one or several dielectrics, such as for example SiO_2 . In particular, Ge can also be combined with Si in order to achieve the desired effects.

The three embodiments have been described in the present case with primer. Such a lacquer layer, which is placed between the PVD layer and the substrate, can be called a basecoat. If desired, it is possible to do without this basecoat.

An electronic proximity sensor with a sensor element placed below a decorative surface has been described, whose decorative surface is coated with a thin semiconductor layer. In the frame of this description, a semiconductor layer designates a layer comprising at least one semiconductor. The semiconductor layer preferably has a thickness between 10nm and 100nm. Preferably, the semiconductor layer comprises silicon as semiconductor material. Even more preferably, the semiconductor layer consists of silicon.

The semiconductor layer can be a component of a layer system comprising at least one further layer, which is preferably an interference layer system. The at least one other layer can be a SiO_2 layer. The layer system can preferably be an alternating layer system. Between the component forming the decorative surface and the semiconductor layer, it is possible to provide an intermediary layer comprising a polymer layer that preferably consists of a UV-hardened lacquer. It is possible to provide as a sealing layer against the environment a polymer coating, which preferably consists of a UV-hardened lacquer. The electronic proximity sensor can constitute a proximity circuit.

A method for producing an electronic proximity sensor has been described, having the steps of:

- providing an electronic proximity sensor having a decorative surface
- coating the decorative surface with a semiconductor layer, the thickness of which is between 10nm and 100nm, wherein the coating is achieved by means of a vacuum process. The vacuum process is preferably a PVD and/or a CVD process.

Claims

1. An electronic proximity sensor comprising:
 - a decorative surface made of a synthetic material;
 - a capacitive sensor element placed below the decorative surface disposed in such a manner that the sensor element can detect by means of capacitive evaluation whether a finger is moving closer to a sensor surface and thus whether switching functions must be executed;
 - wherein the decorative surface is coated with a coating comprising at least one thin layer made of a semiconductor material which provides metallic gloss to the decorative surface and which allows transmission of electromagnetic rays, wherein the coating comprises a primer UV acryl lacquer layer provided as intermediate layer between the decorative surface and the at least one thin layer made of a semiconductor material in order to smooth any potential surface structure,
 - wherein the at least one thin layer made of semiconductor material is a layer made of silicon or germanium or silicon and germanium.
2. Electronic proximity sensor according to claim 1 wherein the at least one thin layer made of semiconductor material is one layer in a layer system comprising thin layers made of semiconductor material and layers made of dielectric material, wherein the both kind of layers are provided forming an alternating layer system.
3. Electronic proximity sensor according to any one of claim 1 or 2, wherein the thickness of the thin layer made of a semiconductor material or the total thickness of the thin layers made of a semiconductor material is between 10nm and 100nm.

4. Electronic proximity sensor according to any one of claim 2 or 3, wherein the dielectric material in the layers made of dielectric material is SiO₂.
5. Electronic proximity sensor according to any one of the preceding claims, wherein the coating comprises a top layer provided as a sealing layer against the environment and this layer being a UV-hardened acryl lacquer layer.

6. Electronic proximity sensor according to any of the preceding claims, wherein the decorative surface is a synthetic surface of an automobile interior component.

7. Method for producing an electronic proximity sensor, the method comprising the steps of:

- providing a decorative surface, the decorative surface comprising synthetic material;
- providing an electronic proximity sensor having a capacitive sensor element placed below the decorative surface, such that the sensor element can detect by means of capacitive evaluation whether a finger is moving closer to a sensor surface and thus whether switching functions must be executed;
- coating the decorative surface with a primer UV acryl lacquer layer, the primer UV acryl lacquer is configured to smooth any potential surface structure;
- coating the decorative surface with a semiconductor layer, such that the semiconductor layer provides metallic gloss to the decorative surface and allows transmission of electromagnetic rays;
- wherein the semiconductor layer is a layer made of silicon or germanium or silicon and germanium.

8. The method of claim 7, the thickness of the semiconductor layer is between 10nm and 100nm, wherein the coating is achieved by means of a vacuum process.

9. Method according to claim 8, wherein the vacuum process is preferably a PVD and/or a CVD process.