COMPONENT WITH SURFACE ACOUSTIC WAVES ELIMINATING PYROELECTRIC INTERFACE

The field of the invention is that of surface acoustic wave devices. The use of these devices is becoming ever greater, especially in filtering applications for telecommunications such as mobile radio telephony or base stations, on account of their compactness, their low cost and their ease of use.

These filters are used just as much for analogue as for digital applications and are inserted into low-level electronic circuitry.

This surface wave filtering technology nevertheless has the drawback that in certain cases unwanted spikes, of pyroelectric origin, which are inherent in the material and are related to the temperature variations under the operating conditions of the filter, are generated inopportunely.

Thus, depending on the intended applications it may be advisable to use filters based on piezoelectric material such as lithium niobate or alternatively lithium tantalate. These piezoelectric materials are also pyroelectric and exhibit spontaneous variation of polarization as a function of the temperature. The relationship between the temperature variation DT and the polarization variation DP is linear and can be written in the form DP = pDT where p is the pyroelectric tensor. In tensor notation, the formula may be written Dpi = piDT. In materials such as lithium niobate, the pyroelectric effect is due to the motion of the niobium and lithium ions relative to the oxygen layers. Since the Li and Nb ions move solely in the direction parallel to the axis c of the lithium niobate crystal, the pyroelectric tensor is of the form:

$$pi = \begin{bmatrix} 0 \\ 0 \\ p3 \end{bmatrix}$$

The same reasoning can be applied in respect of the lithium tantalate crystal, the Ta ion then taking the place of the Nb ion.

In the case of both of these crystals, the pyroelectric component p_i is a negative constant, which explains why when these materials are cooled, that face of the lithium niobate or lithium tantalate substrate out of which the positive direction of the c axis (+ c) emerges will be positively charged.

Generally, in a surface wave device, which faces are charged by the pyroelectric effect will depend on the cut used; it could be the surface of the device and/or its extremities. In all cases, after the application of a temperature variation and the formation of surface charges, the relaxation of the charge may occur in two ways:

- slowly: the charges gradually return to their place within the material and the device exhibits no defect;
- abruptly: the charges are removed by any physical phenomenon capable of transporting energy (the striking of a plasma for example) and the device exhibits malfunctions which show up as the appearance of unwanted spikes in a frequency response curve of the relevant transducer.

This happens because the appearance of the surface charges creates an electric field which, through the antenna effect, disturbs the electric field at the interdigital output electrodes via which the output signal is recovered.

Certain solutions have been envisaged for promoting the flow of the pyroelectric charges. In particular, the introduction of a choke into the impedance matching circuit of an electroacoustic transducer between the output of the transducer and the earth has been envisaged.

However, this solution has proved to be inefficient in so far as the pyroelectric charges do

not flow continuously on account of the choke introduced into the circuit.

It is for this reason that, in order to alleviate the pyroelectric phenomenon problem, the invention proposes a surface acoustic wave device comprising a piezoelectric substrate from which the pyroelectric charges can be removed to an earth by virtue of regions of the substrate which are rendered sufficiently conductive and are connected to the said earth.

More precisely, the subject of the invention is a surface acoustic wave device comprising a substrate made of piezoelectric and pyroelectric material with electrical conductivity σ_0, comprising on one of its faces an electroacoustic transducer linked to an input, an output and an earth, the said material exhibiting electric polarization $\vec{P}$, characterized in that the faces of the planes perpendicular to the polarization $\vec{P}$ have an electrical conductivity σ greater than the electrical conductivity σ_0, and are linked to the earth in such a way as to allow the flow of pyroelectric charges which appear during the operation of the electroacoustic transducer.

According to a variant of the invention, the relevant faces are rendered more conductive by depositing a conductive film, when these faces are not those on which the electroacoustic transducer is placed.

According to a variant of the invention, when the relevant face to be rendered more conductive is that on which the electroacoustic transducer is placed, this face can undergo ion implantation so as to obtain the required electrical conductivity or else a very fine layer of semiconductor material can be interposed between the said face and the electroacoustic transducer.

Advantageously, the piezoelectric material can be of the lithium niobate or lithium tantalate type.

The invention will be better understood and other advantages will emerge on reading the following description given by way of non-limiting example and with the aid of the appended figures in which:

- Figure 1 illustrates an example of a surface acoustic wave device according to the invention comprising a substrate which can be of the Y-Z lithium niobate type (Y cut, propagation along Z);
- Figure 2 illustrates the surface acoustic wave device of the example illustrated in Figure 1, the faces being rendered conductive by depositing a conductive film;
- Figure 3 illustrates an example of a surface acoustic wave device according to the invention comprising a substrate of the lithium tantalate type cut at 112° to the c axis;
- Figure 4 illustrates an example of a surface acoustic wave device according to the invention, comprising a substrate of the lithium niobate type, cut at 128°C [sic] to the c axis.

According to a first variant of the invention, the surface acoustic wave device comprises a substrate of the Y-Z lithium niobate type which is especially beneficial as a filter around 140 MHz. In this type of substrate, the polarization of the material is parallel to the Z axis as illustrated in Figure 1. Such a device comprises 2 sets of interdigital electrodes, consisting respectively of electrode combs 11, 12 and 21, 22. The comb 11 is linked to a control input E, the comb 21 being linked to an earth plane PM. The comb 21 is linked to an analysis output 21, the comb 22 being likewise linked to the earth plane PM. In a configuration of this kind, the charges related to the pyroelectric effects appear respectively on the faces lying in the planes Pxy and P'xy perpendicular to the

plane Pyz on which the electroacoustic transducer is made from the two series of combs.

According to the invention, the planes Pxy and P'xy are rendered more conductive than the other faces of the piezoelectric substrate so as to allow the flow of the surface charges, of pyroelectric origin, to the earth plane Pm. Thus, by rendering the relevant faces more conductive a reduction is achieved in the time constant RC such that it is rendered smaller than the charging time constant of the material in which the pyroelectric effects occur.

Typically, the faces may be rendered more conductive by depositing a conductive film FC. This conductive film FC can advantageously be a conductive adhesive such as a silver-filled epoxy resin.

In practice, the conductive film can cover the plane Pzy locally, the whole of the planes Pxy and P'xy and the earth plane PM locally so as to ensure good coverage and thus good flow of the charges to the earth plane as illustrated by Figure 2.

According to a second variant of the invention, the surface acoustic wave device is a device comprising a substrate whose polarization possesses a component along the Y axis and a component along the Z axis. It may in particular be a lithium tantalate substrate sectioned at 112 [sic] to the c axis of the crystal, especially beneficial for making filters in digital filtering applications.

The planes Pxy and P'xy perpendicular to the component along the Z axis are rendered conductive, as are the planes Pxz and P'xy perpendicular to the component along the Y axis, of the polarization $\vec{P}$, as illustrated by Figure 3.

The same type of conductive film, e.g. conductive adhesive, as that used in the first variant of the invention can thus be deposited on the whole of the edges of the lithium tantalate piezoelectric crystal.

According to a third variant of the invention, the surface acoustic wave device is a device comprising a substrate whose polarization is emergent with respect to the plane Pyz. The polarization $\vec{P}$ then comprises a non-zero component along the X axis and one or two likewise non-zero components along the Y and/or Z axes as illustrated by Figure 4. This may for example involve substrates of lithium niobate cut at 128° to the c axis or alternatively of lithium tantalate cut at 36° to the c axis of the crystal.

According to the invention, the face in the plane Pyz is rendered more conductive. Nevertheless, it is important that the propagation of the surface acoustic waves be disturbed as little as possible. This compromise can in particular be achieved by carrying out ion implantation on the relevant surface. For example, this may involve ion implantation of boron or of arsine. Typically, the resistivity may vary from a value of $10^{18}\Omega.cm$ to a value of $10^{10}\ \Omega.cm$.

In addition to this surface treatment, in the plane Pyz, a conductive film is deposited on the other faces perpendicular to components of the polarization of the piezoelectric substrate.

The partial coverage of the plane Pyz by the conductive film, as illustrated in Figure 2, in this case allows efficient flow of the surface charges which have appeared in the same plane Pyz, towards the earth plane.

Another alternative to ion implantation is the deposition of a very fine layer of semiconductor material, having an electrical conductivity sufficient to allow the flow of charges and the weakest possible disturbance to the propagation of the surface acoustic waves. Silicon fulfils these various functions. Indeed, current techniques make it possible to control the deposition of layers of silicon of atomic thickness (less than 10 Å) in such a way as to modify the electrical conductivity of the face Pyz without excessively modifying its electroacoustic properties,

and to do so in such a way that the discharge time constant becomes less than the charging time constant.

* C L M S *

CLAIMS

1. Surface acoustic wave device comprising a substrate made of piezoelectric and pyroelectric material with electrical conductivity σ_0, comprising on one of its faces an electroacoustic transducer linked to an input (E), an output (S) and an earth (PM), the said material exhibiting electric polarization $\vec{P}$, characterized in that the faces of the planes perpendicular to the polarization $\vec{P}$ have an electrical conductivity σ greater than the electrical conductivity σ_0, and are linked to the earth (PM) in such a way as to allow the flow of pyroelectric charges which appear during the operation of the electroacoustic transducer.

2. Surface acoustic wave device according to Claim 1, characterized in that the polarization $\vec{P}$ possesses a vector component in a plane parallel to the plane Pyz of the face on which the electroacoustic transducer lies, the faces Pxy and/or Pxz perpendicular to the plane Pyz being covered with a conductive film.

3. Surface acoustic wave device according to Claim 2, characterized in that the substrate is deposited on an earth plane (PM), the conductive film partially covering the said earth plane and the plane Pyz of the face on which the electroacoustic transducer lies.

4. Surface acoustic wave device according to one of Claims 1, 2 and 3, characterized in that the piezoelectric and pyroelectric material is lithium niobate.

5. Surface acoustic wave device according to either of Claims 2 and 3, characterized in that the piezoelectric and pyroelectric material is lithium tantalate.

6. Surface acoustic wave device according to one of Claims 1 to 3, characterized in that the polarization $\vec{P}$ possesses a vector component in a plane perpendicular to the plane Pyz, the face on which the electroacoustic transducer lies being rendered more conductive by ion implantation.

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7. Surface acoustic wave device according to one of Claims 1 to 3, characterized in that the polarization $\vec{P}$ possesses a vector component in a plane perpendicular to the plane Pxy, the face on which the electroacoustic transducer lies possessing a very fine layer of semiconductor material of the silicon type.

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