However, since the piezoelectric material and the material of the carrier substrate have very different thermal expansion coefficients, implementing such an annealing causes the assembly to deform substantially.

To overcome this type of problem, it is known practice to use a donor virtual substrate, that is to say a heterostructure in which the thick piezoelectric substrate is bonded to a handle substrate. Thus, after bonding said donor virtual substrate and the carrier substrate, the thick piezoelectric substrate is held between the handle substrate and the carrier substrate. The choice of materials and thicknesses of the handle substrate and of the carrier substrate makes it possible to ensure a certain symmetry of the thermal expansion coefficients, and thus to minimize the deformation of the assembly during the application of heat treatments.

The donor virtual substrate could thus be produced by joining the thick piezoelectric substrate and a silicon substrate, each covered with an oxide layer.

However, such a heterostructure has several drawbacks.

First, depositing an oxide layer on the thick piezoelectric substrate causes said piezoelectric substrate to curve (bow) substantially, which is not very compatible with the later steps of the process, which are designed for flat substrates.

Furthermore, the formation of the oxide layers required for bonding is lengthy and expensive.

Lastly, as mentioned above, the heterostructure cannot undergo the consolidating anneal because of the differences in thermal expansion coefficients between the thick piezoelectric substrate and the handle substrate. However, in the absence of the consolidating anneal, the bonding energy of the oxide layers of the two substrates remains very low, such that the mechanical strength of the donor virtual substrate is insufficient. Consequently, a break at the bonding interface may occur during the step of thinning the thick piezoelectric substrate.

BRIEF DESCRIPTION OF THE INVENTION

Embodiments of the invention seek to overcome the aforementioned drawbacks and in particular to design a donor substrate for the transfer of a thin piezoelectric layer from a thick substrate to a carrier substrate, which may be less expensive to produce, which may have better mechanical strength and/or which may have a lower curvature than existing substrates.

There is disclosed a process for producing a donor substrate for the transfer of a piezoelectric layer to a carrier substrate, said process being mainly characterized in that it comprises the following steps:

- providing a piezoelectric substrate;

- providing a handle substrate;
- depositing a photopolymerizable adhesive layer on a main face of the handle substrate or of the piezoelectric substrate;
- bonding the piezoelectric substrate to the handle substrate via the adhesive layer, to form a heterostructure;
- irradiating said heterostructure with a light flux in order to polymerize the adhesive layer, so as to form said donor substrate.

Implementing a photopolymerizable adhesive layer to assemble the heterostructure making up the donor substrate may make it possible to endow said substrate with good mechanical strength while avoiding the process steps implemented at high temperature that are liable to cause the substrate to curve substantially. Furthermore, the formation of such an adhesive layer may be very straightforward to implement and may be inexpensive.

According to the disclosure, the proposed production process has the following various features, which may be implemented alone or in technically feasible combinations thereof:

- the thickness of the photopolymerizable adhesive layer is between 2 μm and 8 μm;
- the photopolymerizable adhesive layer is deposited by spin coating;
- the bonding step is implemented at a temperature of between 20°C and 50°C, preferably between 20°C and 30°C;
- the light flux is applied through the piezoelectric substrate;
- the irradiation is pulsed;
- the light flux has a wavelength of between 320 nm and 365 nm;
- the handle substrate and the carrier substrate are made of materials such that the difference in thermal expansion coefficient between the material of the handle substrate and the material of the carrier substrate is less than or equal to 5%, and preferably approximately equal to 0%;
- the handle substrate is made of silicon, of sapphire, of polycrystalline aluminum nitride (AlN), or of gallium arsenide (GaAs).

An aspect of the invention relates to a process for transferring a piezoelectric layer to a carrier substrate, comprising:

- providing a donor substrate consisting of a heterostructure comprising a piezoelectric substrate bonded to a handle substrate, and a polymerized adhesive layer at the interface between the piezoelectric substrate and the handle substrate;

- forming a weakened zone in the piezoelectric substrate, so as to delimit the piezoelectric layer to be transferred;
- providing the carrier substrate;
- forming a dielectric layer on a main face of the carrier substrate and/or of the piezoelectric substrate;
- bonding the donor substrate to the carrier substrate, said dielectric layer being at the bonding interface;
- splitting and separating the donor substrate along the weakened zone, at a temperature less than or equal to 300°C.

According to example embodiments, the transfer process has the following various features, which may be implemented alone or in technically feasible combinations thereof:

- the dielectric layer is a glass layer deposited by spin coating on the piezoelectric substrate;
- the process comprises, prior to bonding, the formation of an oxide layer, or a nitride layer, or a layer comprising a combination of nitride and oxide, or a superposition of at least one oxide layer and one nitride layer on the carrier substrate;
- the weakened zone is formed by implanting atomic species into the piezoelectric substrate;
- the handle substrate is a substrate made of silicon, of sapphire, of polycrystalline aluminum nitride (AlN), or of gallium arsenide (GaAs);
- the thickness of the polymerized adhesive layer is between 2 μm and 8 μm.

Another aspect of the invention relates to a process for producing a bulk acoustic wave device, comprising the deposition of electrodes on two opposite faces of a piezoelectric layer. This process is mainly characterized in that it comprises producing said piezoelectric layer by means of a transfer process described above.

There is also disclosed a donor substrate for the transfer of a piezoelectric layer, consisting of a heterostructure comprising a piezoelectric substrate bonded to a handle substrate. The substrate is mainly characterized in that it comprises, at the interface between the piezoelectric substrate and the handle substrate, a polymerized adhesive layer.

CLAIMS

1. A process for transferring a piezoelectric layer to a carrier substrate, comprising:
- providing a donor substrate consisting of a heterostructure comprising a piezoelectric substrate bonded to a handle substrate, and a polymerized adhesive layer at the interface between the piezoelectric substrate and the handle substrate;
- forming a weakened zone in the piezoelectric substrate, so as to delimit the piezoelectric layer to be transferred;
- providing the carrier substrate;
- forming a dielectric layer on a main face of the carrier substrate and/or of the piezoelectric substrate,
- bonding the donor substrate to the carrier substrate, said dielectric layer being at the bonding interface;
- splitting and separating the donor substrate along the weakened zone, at a temperature less than or equal to 300°C.

2. The process as claimed in claim 1, wherein the dielectric layer is a glass layer deposited by spin coating on the piezoelectric substrate.

3. The process as claimed in claim 1 or claim 2 comprising, prior to bonding, the formation of an oxide layer, or a nitride layer, or a layer comprising a combination of nitride and oxide, or a superposition of at least one oxide layer and one nitride layer on the carrier substrate.

4. The process as claimed in any one of claims 1 to 3, wherein the weakened zone is formed by implanting atomic species into the piezoelectric substrate.

5. The process as claimed in any one of claims 1 to 4, wherein the handle substrate is a substrate made of silicon, of sapphire, of polycrystalline aluminum nitride (AlN) or of gallium arsenide (GaAs).

6. The process as claimed in any one of claims 1 to 5, wherein the thickness of the polymerized adhesive layer is between 2 µm and 8 µm.

7. A process for producing a bulk acoustic wave device, comprising the deposition of electrodes on two opposite faces of a piezoelectric layer, characterized in that it comprises producing said piezoelectric layer by means of a process as claimed in one of claims 1 to 6.