

Description**Title: Refreshing of a Donor Substrate for the Manufacture of a POI Structure**

The present invention relates to the refreshing process of donor substrates for the manufacture of Piezo on Insulator, POI, structures, in particular, POI structures usable for the manufacturing of microelectronic, micromechanical and photonic devices. Further, the invention relates to the manufacturing process of POI structures by means of thus refreshed donor substrates.

10 In the field of microelectronics, micromechanics and photonics POI structures are of increasing importance due to superior sensibility and information propagation properties, for example. For example, sensors as surface acoustic wave (SAW) sensors, or bulk acoustic wave (BAW) sensors utilizing the piezoelectric effect to transduce an electrical signal into a mechanical / acoustic wave offer particularly advantageous options due to
15 a wide variety of measurable ambient parameters including temperature, pressure, strain and torque, for example.

A typical POI structure comprises a layer of piezoelectric material, in particular, a single-crystal material, such as, for example, lithium niobate (LiNbO_3) or lithium tantalate
20 (LiTaO_3), on a support substrate, for example, made of silicon. Various processes of forming a thin layer of piezoelectric material on the support substrate are known in the art. Application of the Smart Cut™ technology has been proven particularly advantageous. According to this technology (see, for example, WO 2020/200986 A1), a piezoelectric substrate formed on a support substrate is implanted by light species to form a
25 weakened region in the piezoelectric substrate and afterwards the piezoelectric substrate is bonded to a target substrate. By fracture at the weakened region the thin layer of piezoelectric material can be obtained on the support substrate. The transferred layer of piezoelectric material is subject to an annealing process and, subsequently, a polishing process, particular, by chemical mechanical polishing, CMP, in an attempt to im-
30 prove the crystalline quality and achieve the desired thickness uniformity of a mono-domain layer of piezoelectric material with substantially all dipole moments being aligned parallel to each other in a given direction.

A big advantage of the Smart Cut™ technology is that the expensive donor substrate can be reused several times for several subsequent transfer processes of thin piezoelectric layers to target substrates. Before reuse after transfer of a piezoelectric layer to a target substrate the donor substrate has to be refreshed/reconditioned. In particular, a rim/crown at the edge of the piezoelectric substrate after fracture at the weakened region and transfer of the piezoelectric layer remains due to imperfect bonding.

It is an object of the present invention to provide a technique of refreshing a donor substrate after transfer of a piezoelectric layer to a target substrate to provide a refreshed donor substrate comprising an upper portion with an exposed surface such that a highly uniform layer of piezoelectric material can be transferred from the refreshed donor substrate to another target substrate.

The present invention addresses this object by providing a method of refreshing (reconditioning) a donor substrate for the manufacture of a Piezoelectric on Insulator, POI, structure. The method comprises providing the donor substrate to be refreshed comprising a support substrate and a first piezoelectric substrate formed over the support substrate comprising or consisting of one of lithium tantalate and lithium niobate, wherein the first piezoelectric substrate is a second piezoelectric substrate from which a piezoelectric layer has been transferred to a target substrate. In other words, the donor substrate to be refreshed was already used for transferring a piezoelectric layer to a target substrate for the manufacture of a POI structure and the donor substrate is to be refreshed for a further transfer of a piezoelectric layer to another target substrate. A dielectric bonding layer, for example, a photo (UV) polymer layer or a layer made of or comprising silicon oxide and/or silicon nitride may be present between the support substrate and the first piezoelectric substrate.

The method further comprises chemical-mechanical polishing, CMP, the first piezoelectric substrate to obtain a refreshed donor substrate comprising a refreshed piezoelectric substrate. The CMP comprises removing a layer of the first piezoelectric substrate with a thickness of at most 2 μm , in particular, at most 1.2 μm (the thickness being measured in the crown region). The method may further comprise implanting a species (for

example, hydrogen, maybe supplemented by helium) into the refreshed piezoelectric substrate to obtain a weakened layer in the first piezoelectric substrate.

It was observed that the rim/crown left on the (first) piezoelectric substrate of the donor substrate to be refreshed has a relatively high amount of hydrogen (for example, about 10^{21} at/cm²) in the case of hydrogen implantation in the donor substrate before transfer of the piezoelectric layer to the target substrate. Due to this relatively amount of hydrogen, the polishing rate of the crown is significantly higher than that of the central region of the upper portion of the first piezoelectric substrate. The crown is, thus, eliminated rather quickly during the CMP process which helps to reduce the overall amount of polishing as the rest of the wafer is less impacted during the initial polishing treatment of the edge region. Consequently, it is possible to remove only a relatively thin layer of piezoelectric material in order to obtain a refreshed donor substrate ready for subsequent transfer(s) of piezoelectric layer(s) to target substrate(s). The method can be repeated several times for refreshing the donor substrate after the respective transfer processes and, thus, the donor substrate can, advantageously, be reused several times for the manufacture of high-quality POI structures.

Polishing recipes can be conventionally chosen. Depending on actual recipes and the material of the piezoelectric substrate as well as the thickness of the piezoelectric layer transferred from the second substrate a layer of the first piezoelectric substrate may be removed during the CMP with a thickness in the range of 2 μ m to 1.2 μ m, in particular, in the range of 1.8 μ m to 1.4 μ m or 1.6 μ m to 1.4 μ m.

The CMP is performed by means of a polishing pad. The polishing pad may comprise a sub pad and a top pad (for contacting the piezoelectric material to be removed). According to an embodiment, a relatively entirely hard CMP pad comprising a sub pad with a hardness of more than 75 shore A and a conventional top pad (for example, a rigid top pad made of polyurethane) is used. The shore A grade may be defined/measured according to the DIN ISO 7619-1 or ASTM D2240-10 standard. In the art, sub pads with a hardness of 53 shore A are commonly used. Depending on the actual application, according to an embodiment, a CMP pad comprising a sub pad with a hardness of more than 80 shore A, in particular, more than 90 shore A, or with a hardness in the range on

75 shore A to 95 shore A, in particular, in a range of 85 shore A to 95 shore A, may be used. According to an example, the top pad and the sub pad may have a similar hardness within the range of 20 or 10 shore A, for example. Usage of such hard sub pads is somewhat counterintuitive in view of a risk of generating scratches in the surface of the piezoelectric layer of the refreshed donor substrate to be transferred. However, it turned out that a uniform thickness of the piezoelectric layer of the refreshed donor substrate to be transferred can be achieved without causing scratches into the surface of that layer.

Other parameters of the entire refreshing process of the donor substrate to be refreshed and a manufacturing process of a POI structure comprising the refreshing process may be chosen as it is done conventionally and known to the skilled person.

According to an embodiment, the sub pad has a density of more than 0.6 g/cm^3 , in particular, more than 0.7 g/cm^3 or 0.8 g/cm^3 , or in the range of 0.6 g/cm^3 to 0.9 g/cm^3 . These parameter ranges may prove advantageous in terms of the thickness uniformity of the resulting polished piezoelectric layer of the refreshed piezoelectric substrate of the refreshed donor substrate, in particular, in combination with the above cited parameter ranges.

According to another embodiment, the sub pad has a compression force deflection of more than 689.476 kPa (100 psi), in particular, 758.423 kPa (110 psi) or 827.371 kPa (120 psi), or in the range of 689 kPa to 900 kPa. The compression force deflection may be defined/measured according to the ASTM D 3574 standard. These parameter ranges may prove advantageous in terms of the thickness uniformity of the resulting polished piezoelectric layer of the refreshed piezoelectric substrate of the refreshed donor substrate, in particular, in combination with the above cited parameter ranges.

According to another embodiment, the CMP is performed by means of a CMP slurry consisting of an aqueous suspension of amorphous silicon with a weight percent of the amorphous silicon of less than 20, in particular, in the range of 10 to 18 or 12.5 to 17.5 contrary to the parameter range of a conventionally used CMP slurry given by 25 to 35 weight percent. The parameter ranges according to the embodiment may prove advantageous in terms of the thickness uniformity of the resulting polished piezoelectric layer

of the refreshed piezoelectric substrate of the refreshed donor substrate, in particular, in combination with the above cited parameter ranges. The amorphous silicon used for the CMP slurry may comprise or consist of precipitated amorphous silicon particles with diameters in the range of 40 to 60 nm.

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For the polishing process, the donor substrate that is to be refreshed is positioned on a rotatable head and contacted with a rotatable polishing pad. According to particular embodiments, the head is rotated 30 to 110 rounds per minute (rpm), in particular, 40 to 105 rounds per minute and the polishing pad is rotated in the same direction as the head at a different speed as compared to the head in the range of 50 to 90 rounds per minute, in particular, 60 to 80 rounds per minute (platen speed). The parameter ranges according to the embodiment may prove advantageous in terms of the thickness uniformity of the resulting polished piezoelectric layer of the refreshed piezoelectric substrate of the refreshed donor substrate, in particular, in combination with the above cited parameter ranges.

According to another embodiment, the wafer pressure applied to the donor substrate to be refreshed to press it against the polishing pad is in the range of 44.8 kPa (6.5 psi) to 58.6 kPa (8.5 psi) and the retainer pressure in the range of 37.9 kPa (5.5 psi) to 44.8 kPa (6.5 psi). These parameter ranges may prove advantageous in terms of the thickness uniformity of the resulting polished piezoelectric layer of the refreshed piezoelectric substrate of the refreshed donor substrate, in particular, in combination with the above cited parameter ranges.

Furthermore, it is provided a method of manufacturing a Piezoelectric on Insulator, POI, structure comprising performing the steps of the method of refreshing a donor substrate according to one of the above-described examples and transferring a piezoelectric layer from the refreshed piezoelectric substrate of the refreshed donor substrate to another target substrate comprising bonding the refreshed donor substrate to the target substrate at the side of the refreshed piezoelectric substrate and fracturing the refreshed piezoelectric substrate at the weakened layer in an anneal process.

Thereby, a uniform piezoelectric layer can be reliably transferred to the other target substrate without too heavy defects. Further post-processing (annealing and polishing) may, however, still be needed to provide a piezoelectric layer suitable for particular applications. It is noted that naturally occurring silicon oxide may be present between the transferred piezoelectric layer and the other target substrate. Further, a dielectric assembly layer may be formed on or over a surface of the other target substrate before transfer of the piezoelectric layer to that surface. This dielectric assembly layer may be made of or comprise silicon oxide and/or silicon nitride or a stack of layers composed of these materials. Moreover, depending on the actual application a charge trapping layer may be formed on or over a surface of the other target substrate before transfer of the piezoelectric layer to that surface. The charge trapping layer may be made of or comprise polycrystalline silicon.

As mentioned above post-processing of the piezoelectric layer transferred to the other target substrate may be performed. The post-processing may comprise a thermal anneal step for increasing the crystalline quality of the transferred piezoelectric layer and consolidating the bonding of the transferred piezoelectric layer to the other target substrate. The post-processing may further comprise CMP of the transferred piezoelectric layer after the thermal anneal in order to increase the thickness uniformity and surface quality and in order to remove multi-domain regions with different polarities caused by the anneal.

Further, it is provided a POI structure comprising a piezoelectric layer formed on or over a target substrate and obtainable by the method according to one of the above-described examples, wherein the piezoelectric layer may exhibit a thickness uniformity (thickness range across the diameter of the layer) of less than 50 nm, in particular, less than 20 nm. Furthermore, it is provided a microelectronic, micromechanical or photonic device or micro-electro-mechanical system (MEMS) comprising such a POI structure.

Additional features and advantages of the present invention will be described with reference to the drawings. In the description, reference is made to the accompanying Figures that are meant to illustrate preferred embodiments of the invention. It is understood that such embodiments do not represent the full scope of the invention.

[Fig. 1] illustrates steps of a method of manufacturing a POI structure according to an embodiment of the present invention.

[Fig. 2] illustrates the effect of a varying platen speed used for CMP of a piezoelectric substrate of a donor substrate to be refreshed on the resulting crown width.

[Fig. 3] illustrates the effect of a varying retainer pressure used for CMP of a piezoelectric substrate of a donor substrate to be refreshed on the resulting crown width.

[Fig. 4] illustrates the effect of a varying platen speed used for CMP of a piezoelectric substrate of a donor substrate to be refreshed on the resulting light point defects.

[Fig. 5] illustrates the effect of a varying retainer pressure used for CMP of a piezoelectric substrate of a donor substrate to be refreshed on the resulting light point defects.

Herein, it is provided a method of refreshing a donor substrate comprising a piezoelectric substrate for the manufacture of a POI structure. Refreshing the donor substrate that was previously used for transferring a piezoelectric layer to a target substrate comprise CMP of the piezoelectric substrate to obtain a refreshed piezoelectric substrate a layer of which can be transferred to a target substrate. According to the invention, only a relatively thin layer of piezoelectric material has to be removed in order to obtain the refreshed piezoelectric substrate providing a piezoelectric layer to be transferred to a target substrate. The piezoelectric layer to be transformed to a target substrate exhibits a high thickness uniformity resulting from the polishing process that is, particularly, performed with a relatively hard CMP polishing pad. The method may be comprised by a method of manufacturing a POI structure according to the Smart Cut™ technology.

Fig. 1 illustrates steps of a method of manufacturing a POI structure according to an embodiment of the present invention. The method is similar to a method described in WO 2020/200986 A1 but differs from the latter one by the inventive process of refreshing the donor substrate.

As shown in step i) of Fig. 1 a donor substrate (pseudodonor) 1 is provided that comprises a piezoelectric substrate 1a formed on a support (manipulator) substrate 1b. The piezoelectric substrate 1a is made of lithium tantalate (LiTaO_3) or lithium niobate (LiNbO_3) and may have thickness of about 20 μm . The support substrate 1b may be

made of a material (or a plurality of materials) with a coefficient of thermal expansion close to that exhibited by a target substrate 7, i.e., the thermal expansion coefficient of the support substrate 1b differs from the one of the target substrate 7 by less than the difference of the thermal expansion coefficient of the piezoelectric substrate 1a and that of the target substrate 7. The support substrate 1b and the target substrate 7 may have identical thermal expansion coefficients and both substrates may, for example, consist of or comprise silicon. Moreover, both substrates may have similar thicknesses.

In order to obtain the donor substrate 1, a massive block of piezoelectric material may be attached to the support substrate 1b, for example, using a molecular adhesion bonding technique. The bonding may be mediated by a dielectric bonding (adhesion) layer (not shown in Fig. 1), for example, a photo (UV) polymer layer or a layer made of or comprising silicon oxide and/or silicon nitride. The bonding process may include the application of a low temperature heat treatment (for example, at a temperature between 50 and 300°C, typically 100°C) making it possible to sufficiently reinforce the bonding energy to allow the following thinning step.

Subsequently, the piezoelectric substrate 1a is formed by thinning, for example, chemical-mechanical polishing (CMP). The thinning step is carried out in such a way that the piezoelectric substrate 1a has a sufficiently low thickness such that the stresses generated during heat treatment applied in a later processing stage are reduced. On the other hand, the thickness has to be sufficiently high in order to provide the piezoelectric layer 3 that is to be transferred to the target substrate 7 or to provide for a plurality of such layers that are to be transferred one after the other in multiple transfer steps (after respective regeneration of the donor substrate 1) to respective target substrates. The thickness of the piezoelectric substrate 1a can be, for example, between 5 and 400 µm, for example, 20 µm or 100 µm or 200 µm.

In step ii) of the method illustrated in Fig. 1 hydrogen (maybe supplemented by helium) is implanted in the piezoelectric substrate 1a through the exposed surface 4 to generate a weakened layer 2 which marks the separation of the piezoelectric layer 3 from the remainder part 5 of the donor substrate 1. The nature and dose of the implanted species and the implantation energy can be chosen according to the thickness of the piezoelectric layer 3 that is to be transferred to the target substrate 7 and the physicochemical

properties of the piezoelectric substrate 1a. For example, for a lithium tantalate substrate a dose of hydrogen ions between 10^{16} and $5 \cdot 10^{17}$ at/cm² with an energy between 30 keV and 300 keV may be implanted to delimit the piezoelectric layer 3 with a thickness of 200 nm to 2000 nm, for example.

5 According to the method illustrated in Fig. 1 the implantation step ii) is followed by the step of attaching iii) the donor substrate 1 to the support substrate 7 at the side of the piezoelectric substrate 1a by molecular adhesion and/or electrostatic bonding. A dielectric assembly layer 7b may be provided between the piezoelectric substrate 1a of the donor substrate 1 and the target substrate 7. The dielectric assembly layer 7b may com-
10 prise an oxide and may be made of or comprise silicon oxide and/or silicon nitride or a stack of layers composed of these materials. Further, a charge trapping layer, for example, made of or comprising polycrystalline silicon, may be formed on or over the target substrate 7 in order to enhance the electrical resistivity of the same if it is desired by an actual application.

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The piezoelectric layer 3 is then detached from the remainder part 5 of the donor substrate 1 to obtain iv) a POI structure 9 comprising the target substrate 7, the dielectric assembly layer 7b (if provided) and the piezoelectric layer 3. Detachment at the weakened layer 2 is facilitated by heat treatment in a temperature range of around 100°C to
20 600° to allow the transfer of the piezoelectric layer 3 to the target substrate 7. Alternatively or additionally detachment at the weakened layer 2 can be facilitated by the application of a blade or a jet of gaseous or liquid fluid or any other mechanical force applied to the weakened layer 2.

25 Post-processing of the transferred piezoelectric layer 3 is necessary to obtain a transferred piezoelectric layer 3 having satisfactory mono-domain crystalline and surface quality (reduced roughness) and thickness uniformity as demanded by actual applications. The post-processing comprises a heat treatment v) of the piezoelectric layer 3, for example, at about 500°C in a neutral atmosphere or an atmosphere comprising oxygen.
30 This heat treatment makes it possible to cure crystalline defects present in the piezoelectric layer and consolidates the bonding between the piezoelectric layer 3 and the target substrate 7. However, the heat treatment causes diffusion of hydrogen contained in the piezoelectric layer 3, particularly in its upper portion (of thickness of about 50 nm or

less, for example) and, thereby, generation of a plurality of ferroelectric domains giving the upper portion a multi-domain character. In fact, the hydrogen implanted in the piezoelectric substrate 1a during the step of defining the piezoelectric layer 3 above the weakened layer 2 is distributed in this substrate according to a profile presenting a concentration peak at the level of the weakening plane 2. After fracture at the weakened layer 2 the piezoelectric layer 3 transferred to the target substrate 7, thus, has a significant concentration of hydrogen and heat treatment leads to the generation of multi-domains, i.e., a plurality of regions exhibiting different polarities. Performance of devices which are intended to be formed on/in the piezoelectric layer 3 would be heavily affected by such multi-domains.

In order to remove the upper multi-domains and increase surface quality and thickness uniformity of the transferred piezoelectric layer 3 the post-processing comprises polishing of the exposed surface of the piezoelectric layer 3 (see step vi) in Fig. 1). For example, 100 to 300 nm of the upper part of the piezoelectric layer 3 may be removed by the polishing process to reach a pre-determined target thickness, for example, of about 600 nm.

The remainder 5 of the donor substrate 1 represents a donor substrate 50 to be refreshed in step vii). Refreshment of the donor substrate 50 to be refreshed comprises CMP of the piezoelectric substrate 10a that is the remainder of the piezoelectric substrate 1a resulting from the detachment of the piezoelectric layer 3. According to the invention, only a relatively thin upper layer of the piezoelectric material of the piezoelectric substrate 10a has to be removed by CMP in order to provide a new piezoelectric layer of a refreshed piezoelectric substrate to be transferred to another target substrate. The thickness (measured in the crown region) of the relatively thin upper layer of the piezoelectric material of the piezoelectric substrate 10a that has to be removed by CMP is at most 2 μm , in particular, at most 1.2 μm and may be in the range of 2 μm to 1.2 μm , in particular, in the range of 1.8 μm to 1.4 μm or 1.6 μm to 1.4 μm . The thickness depends on the thickness of the transferred piezoelectric layer 3 and the actual hydrogen content of the crown of the donor substrate 50 to be refreshed that remains at the edge of the piezoelectric substrate 1a, 10a after detachment of the piezoelectric layer 3. The crown may have a width of 2 to 3 mm and a thickness of 0.9 μm or 1.2 μm . For example, for a

crown with a thickness of 0.9 μm a layer of piezoelectric material of the piezoelectric substrate 10a with a thickness of 1.4 μm has to be removed only and for a crown with a thickness of 1.2 μm a layer of piezoelectric material of the piezoelectric substrate 10a with a thickness of 1.6 μm has to be removed only.

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After completion of the CMP of the donor substrate 50 the polished donor substrate 50 to be refreshed may be subject to steps ii) to vii) described above and the overall procedure can be repeated until no sufficiently thick piezoelectric layer remains atop of the support substrate 1b.

- 10 In particular, the polished donor substrate 50 to be refreshed may be implanted with hydrogen (maybe supplemented by helium) to generate a weakened layer which marks the separation of the piezoelectric layer from the remainder part of the refreshed donor substrate. The nature and dose of the implanted species and the implantation energy can be chosen according to the thickness of the piezoelectric layer that is to be transferred to a target substrate and the physicochemical properties of the refreshed piezoelectric substrate. For example, for a refreshed piezoelectric substrate made of lithium tantalate a dose of hydrogen ions between 10^{16} and $5 \cdot 10^{17}$ at/cm^2 with an energy between 30 keV and 300 keV may be implanted to delimit a piezoelectric layer to be transferred with a thickness of 200 nm to 2000 nm to a target substrate.
- 20 The CMP for refreshing the donor substrate 50 to be refreshed may be performed using a relatively hard polishing sub pad. A polishing pad comprises a top pad for contacting the material surface to be polished and a sub pad. While the top pad is conventionally chosen (for example, as a rigid top pad made of polyurethane), according to the invention, the sub pad of the CMP pad used for polishing the upper portion of the piezoelectric substrate and, thereby, the piezoelectric layer to be transferred to a target substrate in the process of manufacturing a POI structure has a hardness of more than 75 shore A. Depending on the actual application, a material with a hardness of more than 80 shore A, in particular, more than 90 shore A, or a hardness in the range on 75 shore A to 95 shore A, in particular, in a range of 85 shore A to 95 shore A may be chosen for the sub pad of the CMP pad. According to an example, the top pad and the sub pad of the CMP pad may have a similar hardness within the range of 20 or 10 shore A.
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By using such a relatively hard sub pad, bonding voids formed in the final POI structure after transfer of a piezoelectric layer from the refreshed piezoelectric substrate can be significantly suppressed. Consequently, a more reliable bonding of the transferred piezoelectric layer to a target substrate can be achieved.

- 5 According to different embodiments the sub pad used for CMP of the piezoelectric substrate of the donor substrate 50 to be refreshed has a density of more than 0.6 g/cm^3 , in particular, more than 0.7 g/cm^3 or 0.8 g/cm^3 , or in the range of 0.6 g/cm^3 to 0.9 g/cm^3 and the sub pad may have a compression force deflection of more than 689.476 kPa, in particular, 758.423 kPa or 827.371 kPa, or in the range of 689 kPa to 900 kPa.

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For example, the sub pad may be made of thermoplastic polyurethane and have a hardness of 91 shore A, density of 0.86 g/cm^3 , compression force deflection of 861.845 kPa (125 psi) and thickness of 0.89 mm (35 mil) compared to a typical conventionally used sub pad used for CMP of a piezoelectric layer of a donor substrate used in a Smart

- 15 Cut™ process for obtaining a POI structure being made of polyurethane and having a hardness of 53 shore A, density of 0.4 g/cm^3 , compression force deflection of 641.212 kPa (93 psi) and thickness of 0.79 mm (31 mil).

- According to an embodiment, the CMP for refreshing the donor substrate 50 to be re-
20 refreshed is performed by means of a CMP slurry consisting of an aqueous suspension of amorphous silicon with a weight percent of the amorphous silicon of less than 20, in particular, in the range of 10 to 18 or 12.5 to 17.5. The amorphous silicon used for the CMP slurry may comprise or consist of precipitated amorphous silicon particles with diameters in the range of 40 to 60 nm. For example, Klebosol 30HB50 having amorphous
25 silicon with 25 to 35 weight percent and an average diameter of the precipitated amorphous silicon particles of 50 nm may be suitably diluted with water, for example, with a 1:1 dilution, in order to obtain the CMP slurry used for CMP for refreshing the donor substrate 50.

- 30 Other parameters of the CMP process for refreshing the donor substrate 50 to be refreshed as well as the overall process of manufacturing the POI structure illustrated in Fig. 1 may be conventionally chosen. Optimization of the parameters for an actual application can readily be done by standard experiments.

For the polishing step vii) of the method illustrated in Fig. 1, the donor substrate 50 to be refreshed is positioned on a rotatable head and contacted with a rotatable polishing pad. According to particular embodiments, the head is rotated 30 to 110 rounds per minute (rpm), in particular, 40 to 105 rounds per minute and the polishing pad is rotated in
5 the same direction as the head at a different speed as compared to the head in the range of 50 to 90 rounds per minute, in particular, 60 to 80 rounds per minute (platen speed).

The wafer pressure applied to the donor substrate 50 to be refreshed to press it against
10 the polishing pad may be in the range of 44.8 kPa (6.5 psi) to 58.6 kPa (8.5 psi) and the retainer pressure applied to the retainer/ring for holding the donor substrate 50 to be refreshed may be in the range of 37.9 kPa (5.5 psi) to 44.8 kPa (6.5 psi).

For example, for refreshing a donor substrate 50 to be refreshed made of lithium tantalite the following parameter result in low edge crack defects and edge bonding voids after bonding to a target substrate:
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For a crown with a thickness of 0.9 μm the head speed is chosen at about 40 rpm and at about 105 rpm for a crown with a thickness of 1.2 μm . The platen speed is about 65
20 rpm. Pressure conditions may depend on wafer size. For 150 mm a wafer pressure of up to 55.2 kPa (8 psi) and for 200 mm a wafer pressure of up to 48.3 kPa (7 psi) are chosen. Pressure used for wafer and ring are 55.2 kPa (8 psi) and 41.4 kPa (6 psi), respectively, for a crown thickness of 0.9 μm and 48.3 kPa (7 psi) and 41.4 kPa (6 psi), respectively, for a crown thickness of 1.2 μm and a 150 mm wafer and a crown thickness of 0.9 μm and a 200 mm wafer.
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For exemplary purposes, Figs. 2 to 5 illustrate advantageous technical effects that can be provided by CMP performed within the above-described parameter ranges for refreshing the donor substrate 50 to be refreshed for a 200 mm wafer. Satisfying reduction of crown widths can be obtained as illustrated in Figs. 2 and 3 and satisfying reduction of light point defects (LPD) representing the number of edge bonding voids and crown defects observed for a final POI structure comprising the piezoelectric layer be-
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fore post-processing CMP of the transferred piezoelectric layer can be obtained as illustrated in Figs. 4 and 5. The abscissa in Fig. 2 shows the platen speed in rpm and the ordinate shows the crown width (CW) in mm (at 3H designating the orientation for the check, for a wafer comprising a flat positioned at 6 H, 3H is on the right side). Accordingly
5 the abscissa in Fig. 3 shows the retainer pressure in psi and the ordinate shows the crown width in mm. The abscissa in Fig. 4 shows the platen speed in rpm and the ordinate shows the LPD in units of $1/\text{cm}^2$. The abscissa in Fig. 5 shows the retainer pressure in psi and the ordinate shows the LPD in units of $1/\text{cm}^2$.

10 Fig. 2 illustrates the effect of a varying platen speed on the resulting crown length. Retainer and wafer pressures are fixed at 41.4 kPa (6 psi) and 48.3 kPa (7 psi), respectively. Increasing the platen speed, advantageously, results in a decrease of the remaining crown length.

15 Fig. 3 illustrates the effect of a varying retainer pressure on the resulting crown length. Platen speed is fixed at 80 rpm. Wafer pressure is fixed at 7 psi. A retainer pressure 6 seems to be preferable with higher reproducibility.

Fig. 4 illustrates the effect of a varying platen speed on the resulting LPD. Retainer and
20 wafer pressures are fixed at 41.4 kPa (6 psi) and 48.3 kPa (7 psi), respectively. Results worsen for platen speeds larger than 65 rpm.

Fig. 5 illustrates the effect of a varying retainer pressure on the resulting LPD. Platen
speed is fixed at 80 rpm. Wafer pressure is fixed at 7 psi. in principle, LPD can be re-
25 duced with increasing retainer pressure.

Claims

1. A method of refreshing a donor substrate (50) for the manufacture of a Piezoelectric on Insulator, POI, structure, comprising
 - 5 providing the donor substrate (50) to be refreshed comprising a support substrate (1b) and a first piezoelectric substrate (10a) formed over the support substrate (1b) comprising or consisting of one of lithium tantalate and lithium niobate, wherein the first piezoelectric substrate (10a) is a second piezoelectric substrate (1a) from which a piezoelectric layer (3) has been transferred to a target substrate (7); and
 - 10 chemical-mechanical polishing, CMP, the first piezoelectric substrate (10a) to obtain a refreshed donor substrate comprising a refreshed piezoelectric substrate, wherein the CMP comprises removing a layer of the first piezoelectric substrate (10a) with a thickness of at most 2 μm , in particular, at most 1.2 μm .
2. The method according to claim 1, wherein a layer of the first piezoelectric substrate (10a) is removed with a thickness in the range of 2 μm to 1.2 μm , in particular, in the range of 1.8 μm to 1.4 μm or 1.6 μm to 1.4 μm .
3. The method according to claim 1 or 2, wherein the CMP is performed by means of a CMP pad comprising a sub pad with a hardness of more than 75 shore A, in particular, more than 80 shore A or 90 shore A, or with a hardness in the range of 75 shore A to 95 shore A, in particular, in a range of 85 shore A to 95 shore A.
4. The method according to claim 3, wherein the sub pad has a density of more than 0.6 g/cm^3 , in particular, more than 0.7 g/cm^3 or 0.8 g/cm^3 , or in the range of 0.6 g/cm^3 to 0.9 g/cm^3 and/or the sub pad has a compression force deflection of more than 689.476 kPa, in particular, 758.423 kPa or 827.371 kPa, or in the range of 689 kPa to 900 kPa.

5. The method according to one of the preceding claims, wherein the CMP is performed by means of a CMP slurry consisting of an aqueous suspension of amorphous silicon with a weight percent of the amorphous silicon of less than 20, in particular, in the range of 10 to 18 or 12.5 to 17.5.
- 5 6. The method according to claim 5, wherein the amorphous silicon comprises or consists of precipitated amorphous silicon particles with diameters in the range of 40 to 60 nm.
- 10 7. The method according to one of the preceding claims, wherein the CMP is performed with a head speed in the range of 30 to 110 rounds per minute, in particular, 40 to 105 rounds per minute, and a platen speed in the range of 50 to 90 rounds per minute, in particular, 60 to 80 rounds per minute.
- 15 8. The method according to one of the preceding claims, wherein the CMP comprises applying a wafer pressure to the donor substrate (50) to be refreshed to press it against a polishing pad in the range of 44.8 kPa to 58.6 kPa and a retainer pressure in the range of 37.9 kPa to 44.8 kPa.
- 20 9. A method of manufacturing a Piezoelectric on Insulator, POI, structure, comprising
- performing the steps of one of the preceding claims; and
- 25 transferring a piezoelectric layer from the refreshed piezoelectric substrate to another target substrate comprising bonding the refreshed donor substrate to the other target substrate at the side of the refreshed piezoelectric substrate and fracturing the refreshed piezoelectric substrate at the weakened layer.
- 30 10. The method according to claim 9, further comprising performing a heat treatment and CMP of the piezoelectric layer transferred to the other target substrate.

11. Piezoelectric on Insulator, POI, structure, comprising a piezoelectric layer formed on or over a target substrate and obtainable by the method according to one of the claims 9 and 10.
- 5 12. Microelectronic, micromechanical or photonic device or micro-electro-mechanical system comprising the POI structure according to claim 11.