

roughness) to be as favourable as possible after transfer in order to ensure that the end specifications are met.

The applicant has observed that, when the splitting wave is initiated after the heat treatment at ambient temperature by applying an energy pulse to the buried weakened plane 2, some useful layers 3 may include, after transfer, marbling-like irregular patterns due to local variations in thickness, the amplitude of which is about a nanometre or half a nanometre. This marbling may be distributed over the entirety of the useful layer 3, or over only a portion thereof. It contributes to the non-uniformity of the useful layer 3.

This type of non-uniformity in the thickness of the useful layer 3 is very difficult to eliminate using the typical finishing techniques (etching, sacrificial oxidation, smoothing heat treatment, etc.) because these techniques are not effective in erasing irregular patterns of this amplitude.

SUMMARY OF THE INVENTION

The present invention relates to a process for transferring a useful layer to a carrier substrate and aims in particular to improve the uniformity of thickness of the transferred useful layers.

According to an aspect of the present invention, there is provided a process for transferring a useful layer to a carrier substrate, comprising the following steps:

- a) providing a donor substrate including a buried weakened plane, the useful layer being delimited by a front face of the donor substrate and the buried weakened plane;
- b) providing a carrier substrate;
- c) joining the donor substrate, by its front face, to the carrier substrate along a bonding interface so as to form a bonded structure;
- d) annealing the bonded structure in order to apply a weakening thermal budget thereto and to bring the buried weakened plane to a defined level of weakening, said anneal reaching a maximum hold temperature;
- e) initiating a splitting wave in the buried weakened plane by applying a stress to the bonded structure, the splitting wave propagating in a self-sustained manner along the buried weakened plane in order to result in the useful layer being transferred to the carrier substrate,

wherein the initiation in step e) takes place when the bonded structure is experiencing a thermal gradient defining a hot region and a cool region of said bonded structure, the stress being applied locally in the cool region, and the hot region experiencing a temperature lower than the maximum hold temperature.

According to other advantageous and non-limiting features of the embodiments of the present invention, taken alone or in any technically feasible combinations:

- the thermal gradient is chosen to be between 20°C et 100°C, preferably between 60°C and 90°C, more preferably about 80°C;
- the maximum hold temperature is between 300°C and 600°C;

CLAIMS

1. Process for transferring a useful layer to a carrier substrate, comprising the following steps:

- a) providing a donor substrate including a buried weakened plane, the useful layer being delimited by a front face of the donor substrate and the buried weakened plane;
- b) providing a carrier substrate;
- c) joining the donor substrate, by its front face, to the carrier substrate along a bonding interface so as to form a bonded structure;
- d) annealing the bonded structure in order to apply a weakening thermal budget thereto and to bring the buried weakened plane to a defined level of weakening, said anneal reaching a maximum hold temperature;
- e) initiating a splitting wave in the buried weakened plane by applying a stress to the bonded structure, the splitting wave propagating in a self-sustained manner along the buried weakened plane in order to result in the useful layer being transferred to the carrier substrate,

wherein the initiation in step e) takes place when the bonded structure is experiencing a thermal gradient defining a hot region and a cool region of said bonded structure, the stress being applied locally in the cool region, and the hot region experiencing a temperature lower than the maximum hold temperature.

2. Transfer process according to claim 1, wherein the thermal gradient is chosen to be between 20°C et 100°C, preferably between 60°C and 90°C, more preferably about 80°C.

3. Transfer process according to claim 1 or 2, wherein the maximum hold temperature is between 300°C and 600°C.
4. Transfer process according to any one of claims 1 to 3, wherein annealing step d) takes place in a heat treatment apparatus and the initiation in step e) takes place when the bonded structure exits said heat treatment apparatus.
5. Transfer process according to claim 4, wherein the heat treatment apparatus is a horizontally or vertically configured oven, suitable for batch-treating a plurality of bonded structures.
6. Transfer process according to any one of claims 1 to 5, wherein the initiation in step e) takes place when the hot region of the bonded structure reaches a temperature between 150°C and 250°C.
7. Transfer process according to any one of claims 1 to 6, wherein the weakening thermal budget is between 40% and 95% of a splitting thermal budget, the splitting thermal budget leading to spontaneous initiation of the splitting wave in the buried weakened plane during the anneal.
8. Transfer process according to any one of claims 1 to 7, wherein the stress is applied at the periphery of the bonded structure by inserting a wedge at the bonding interface of the bonded structure, between chamfered edges of the donor substrate and of the carrier substrate, respectively, of said bonded structure.
9. Transfer process according to any one of claims 1 to 8, wherein the donor substrate and the carrier substrate are made of monocrystalline silicon, and wherein the buried

weakened plane is formed by ion implantation of light species into the donor substrate, said light species being chosen from hydrogen and helium, or a combination of hydrogen and helium.