

Claims

1. A silicon structured device (1), designed to be used in a fabrication process of an interdigitated back contact (IBC) photovoltaic device, comprising:
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- a silicon-based substrate (3) being of p-type or n-type doping and having a first face (3a) defining a horizontal X-Y plane and a vertical direction Z orthogonal to said horizontal X-Y plane;
 - an intrinsic amorphous silicon layer a-Si:H(i) (5) situated on said first face (3a);
 - 10 - a first patterned silicon layer (2), situated on said intrinsic amorphous silicon layer a-Si:H(i) layer (5), comprising a first array of distinct and separated amorphous layer islands (2a-2g) so that between the amorphous layer islands (2a-2g) non-coated intrinsic amorphous silicon (a-Si:H(i)) layer portions (5a-5f) are provided that define an array (2') of interstices (2a'-2g'), said first patterned
 - 15 silicon layer (2) having the same doping as the doping of the silicon-based substrate (3),
 - a second patterned nano-crystalline silicon layer (4) in contact with said first patterned silicon layer (2), comprising a second array of second layer portions (4a-4g), each of said second layer portions (4a-4g) being in contact with one of
 - 20 said first layer portions (2a-2g) and forming an array (40) of silicon structures (12a-12g),

wherein

- said second array of second layer portions (4a-4g) is of the same type of doping than said first patterned silicon layer (2),
- 25 and wherein at least one of said silicon structures (12a, 12g) constitutes a fiducial mark (10) having, in a predetermined wavelength range, a different optical reflectivity (R1), defined to the side away from said substrate (3), than the reflectivity (R0) of said intrinsic amorphous silicon (a-Si:H(i)) layer portions (5a-5f).

2. The silicon structured device (1) according to claim 1, wherein the absolute value of $(R1-R0)/R0$ is between 0.001 and 0.5, preferably between 0.005 and 0.1, more preferable between 0.09 and 0.2 for at least one wavelength, said optical reflectivities $R0$, $R1$ being defined for wavelengths between 300nm and 1000nm.
- 5 3. The silicon structured device (1) according to claim 1 or claim 2, comprising at least two fiducials (10, 10').
4. The silicon structured device (1) according to any one of claims 1 to 3 wherein at least one of said fiducials (10,10') has a different shape and/or or different dimension, in at least one cross section plane (XY, YZ, XZ), than the shape and/or the dimension of said silicon structures (12b-12f).
- 10 5. The silicon structured device (1) according to claim 3 or claim 4, comprising at least 2 fiducial marks (10, 10') having a different shaped cross section in at least one plane parallel to said horizontal X-Y plane.
6. A photovoltaic device comprising a silicon structured device (1) according to any one of claims 1-5, wherein an additional silicon layer (50) is present on said second patterned nano-crystalline silicon layer (4), said additional silicon layer (50) forming mesas (50a-50e) covering said silicon structures (12a-12f) and said interstices (5a-5f), said additional silicon layer (50) having a doping of the other type than said first patterned silicon layer (2), the mesa (50a) on said at least one fiducial (10) having a different reflectivity $R3$ than the reflectivity $R2$ of said interstices (5a-f) so that said at least one fiducial (10) is optically detectable by optical means through said additional silicon layer (50).
- 15 20 7. The photovoltaic device according to claim 6 wherein a transparent and conductive second layer (60) is present on said additional silicon layer (50), second layer (60) covering said mesas (50a- 50g) and said third layer interstices (50b-50f) so that the at least one coated fiducial (50a, 50g) has a reflectivity $R5$ different than the reflectivity $R4$ of its surroundings and so that said at least one coated fiducial (10) is optically detectable by optical means through said additional silicon layer (50) and said second layer (60).
- 25 30 8. A photovoltaic module comprising at least one photovoltaic device according to claim 6 or 7.

9. Method for manufacturing of a silicon structured device (1) according to any one of claims 1 to 5, comprising the steps (a-c) of:
- a. providing a silicon-based substrate (3) having an n-type or a p-type doping and comprising an intrinsic amorphous a-Si:H(i) layer (5) situated on a first face (3a) of said silicon-based substrate (3);
 - b. realizing, on said intrinsic layer (5), a first deposition of an n-type or p-type amorphous silicon layer (2), so as to create a patterned amorphous silicon layer (2) comprising a plurality of distinct and separated amorphous layer islands (2a-2g) separated by interstices (2a'-2'g);
 - c. realizing on each of said amorphous layer islands (2a-2g) a second deposition of a nano-crystalline layer (4) having the same doping type as said amorphous layer (2), so as to create on top of each of said amorphous layer islands (2a-2g), nano-crystalline layer portions (4a-4g), to form an array of silicon structures (12a-12f), while choosing the thickness (t) of said first amorphous layer portions (2a-2g) so that at least one fiducial (10) is formed that has a different optical reflectivity (R1), defined to the side away from said substrate (3), than the reflectivity (R0) of the said intrinsic amorphous silicon (a-Si:H(i)) layer portions (5a-5f).
10. Method according to claim 9 wherein the deposition of said amorphous layer islands (2a-2g) and the deposition of the nanocrystalline layer islands (4a-4g) are made through the same mechanical mask.
11. Method of realizing a photovoltaic device comprising the steps of:
- providing a silicon structured device 1 fabricated according to the steps of claims 9 or 10;
 - performing after **step c**, a **step d** consisting in depositing, on top of the silicon structures (12a-12f), and said intrinsic amorphous silicon (a-Si:H(i)) layer portions (5a-5f), a full area semiconductor layer (50), having a doping type different than the doping type of said second nano-crystalline layer (4) so that

said at least one fiducial (10, 10') may be detected by optical means through said full area semiconductor layer (50).

12. Method according to claim 11, wherein after said **step d**, a **step e** is realized consisting in depositing a second layer (60) on top of said semiconductor layer (50) and so that said at least one fiducial (10, 10') may be detected by optical means through said full area semiconductor layer (50) and second layer (60).
13. Method according to claim 12, wherein the thickness (t2) of said second layer (60) is chosen so that, by constructive interference, reflected light off said at least one fiducial (10, 10') is transmitted through said second layer (60), in at least one wavelength range defined in the UV, visible or infrared optical spectrum.
14. Method according to any one of claims 9 to 13, wherein the realization of said at least one fiducial (10, 10') is made by using a mask (100') comprising at least one conical shape aperture, said conical shape being defined in at least one plane orthogonal to said horizontal X-Y plane and so that at least one fiducial (10, 10') has a greater height (h) than said electric charge collection structures (12b-12f).
15. Use of a silicon structured device (1) according to any one of claims 1 to 5 to realize a photovoltaic device.
16. Use of at least one photovoltaic device according to claim 6 or 7 to realize a photovoltaic module.