CLAIMS

1. A method of ion implantation comprising:

providing a first single type of dopant material to a plasma generator;

operating the plasma generator to break up the first single type of dopant material into a first plurality of dopant species; and,

implanting a substrate with the first plurality of dopant species.

2. The method of claim 1, wherein the substrate is implanted with the first plurality of dopant species in a single implantation step.

3. The method of claim 1, wherein each one of the dopant species is implanted into the substrate at a different depth.

4. The method of claim 1, wherein the first single type of dopant material is phosphine.

5. The method of claim 4, wherein the first plurality of dopant species comprises P^+, P^{++}, P^{+++}, P_2^+, P_3^+, and P_5^+.

6. The method of claim 1, wherein the first single type of dopant material is boron or arsenic.

7. The method of claim 1, wherein:

a second single type of dopant material is provided to the plasma generator;

the plasma generator breaks up the second single type of dopant material into a second plurality of dopant species during the same period that the plasma generator breaks up the first single type of dopant material into the first plurality of dopant species; and

the second plurality of dopant species is implanted into the substrate during the same period that the first plurality of dopant species is implanted into the substrate.

8. The method of claim 7, wherein the first single type of dopant material and the second single type of dopant material are each a precursor gas.

9. The method of claim 8, wherein the first single type of dopant material is arsine and the second single type of dopant material is phosphine.

10. The method of claim 1, further comprising pulses of negative potential to the substrate.

11. The method of clam 1, wherein multiple substrates are implanted simultaneously.

12. The method of claim 1, further comprising using a shadow mask to form selective emitter regions in the substrate.

13. The method of claim 12, further comprising adjusting proximity of the shadow mask to the substrate to use beam flare-out.

14. The method of claim 1, further comprising providing a back surface antenna made into a closed loop control so that plasma is directed selectively into certain regions of the substrate.

15. The method of claim 1, wherein plasma ions are accelerated towards the substrate by application of a DC or pulsed potential to a first grid plate.

16. The method of claim 15, wherein deleterious effect of secondary electrons resulting from impingement of ions on the substrate and other materials is avoided through use of a second grid plate which is negatively-biased with respect to the first grid plate.

17. The method of claim 16, further comprising a third grid plate that acts as a beam defining grid and is grounded.

18. The method of claim 17, wherein the third grid plate is positioned in contact with or very close to the surface of the substrate in order to provide a final definition of the implant.

19. The method of claim 1, wherein for the selective implantation, the substrate is moved close to a multiple grid plate assembly, whereas, for the homogenous implantation, the substrate is moved far enough from the grid plate assembly to provide a uniform beam, which is formed as a result of space charge expansion of the beam-lets.

20. The method of claim 1, wherein implanting a substrate with the first plurality of dopant species comprises:

flowing ions from the plasma through apertures in a positively-biased first grid plate;

flowing at least a portion of the ions that flowed through the apertures in the positively-biased first grid plate through apertures in a negatively-biased second grid plate; and,

flowing at least a portion of the ions that flowed through the apertures in the negatively-biased second grid plate through apertures in a third grid plate.

CLAIMS

1. A plasma grid implantation system for fabricating solar cells from a substrate, comprising: a plasma source configured to provide plasma in a plasma region; a first grid plate comprising a plurality of apertures configured to allow ions from the plasma region to pass through the first grid plate, wherein the first grid plate is positively biased by a power supply; a second grid plate comprising a plurality of apertures configured to allow the ions to pass through the second grid plate subsequent to the ions passing through the first grid plate, wherein the second grid plate is negatively biased by a power supply; a third grid plate disposed between the second grid plate and the substrate holder, the third grid plate comprising a plurality of apertures configured to allow the ions to pass through the third grid plate subsequent to the ions passing through the second grid plate, wherein the third grid plate is coupled to ground potential; a substrate holder configured to support the substrate in a position where the substrate is implanted with the ions subsequent to the ions passing through the third grid plate to thereby dope the substrate and fabricate a solar cell; a chamber defined by chamber walls, wherein the plasma region, the first grid plate, the second grid plate, and the third grid plate are housed within the chamber; and, a conveyor belt transporting the substrates from an atmospheric side to vacuum side inside the chamber; wherein: the position of at least one of the first grid plate, the second grid plate, and the substrate holder is configured to be adjusted between a homogeneous implantation position and a selective implantation position; the homogeneous implantation position is configured for a single laterally-homogeneous ion implantation across the substrate on the substrate holder, wherein the single laterally-homogeneous ion implantation is formed from a combination of beamlets that have passed through different apertures of the third grid plate and combined by space charge expansion into a uniform beam; the selective implantation position is configured for a plurality of laterally spaced-apart ion implantations of the substrate on the substrate holder, wherein the plurality of laterally spaced-apart ion implantations is formed from individual ion beamlets that have passed through the different apertures of the third grid plate; and, wherein the first grid plate, the second grid plate and the third grid plate form a grid plate assembly, wherein the grid plate assembly is configured to focus the beamlets into known shapes onto the substrate to thereby form the selective implantation.

2. The system of claim 1, wherein:
the conveyor is configured to transport multiple substrate for simultaneous homogeneous implantation, followed by simultaneous selective implantation.

3. The system of claim 1, wherein the apertures of at least one of the first grid plate and the second grid plate are substantially circular holes.

4. The system of claim 1, wherein the apertures of at least one of the first grid plate and the second grid plate are elongated slots.

5. The system of claim 3, wherein each one of the circular hole apertures of at least one of the first grid plate and the second grid plate comprises a top end and a bottom end, wherein the bottom end is closer to the substrate holder than the top end, and wherein the diameter of each aperture gradually increases from the top end to the bottom end.

6. The system of claim 1, wherein the first grid plate and the second grid plate comprise a material chosen from the group consisting of: silicon, graphite, silicon carbide, and tungsten.

7. The system of claim 1, wherein the chamber walls are configured to repel ions in the plasma region using a magnetic field to push the plasma off the chamber walls.

8. The system of claim 7, wherein one or more magnets are coupled to the chamber walls.

9. The system of claim 1, wherein the first grid plate is configured to be DC positively-biased, either in continuous mode or in pulsed mode.

10. The system of claim 1, further comprising a first pulse forming network coupled to the second grid plate such that the second grid plate is configured to be DC negatively-biased, in pulsed mode.

11. The system of claim 1, wherein the first grid plate, the second grid plate, and the substrate holder are all configured to have their positions adjustable.

12. The system of claim 1, wherein the third grid plate is removable.

13. The system of claim 1, wherein the first grid plate and the second grid plates are configured to accelerate ions from the plasma and minimize back streaming electrons.

14. The system of claim 10, further comprising a second pulse-forming network coupled to the plasma source and in modulation with the first pulse-forming network.

15. The system of claim 1, further comprising a high-voltage pulser coupled to the substrate holder to negatively bias the substrate.

16. The system of claim 1, further comprising a shadow mask positioned close to the third grid plate.

17. The system of claim 1, further comprising a hard mask placed in contact with the substrate.

18. The system of claim 1, wherein the chamber walls are configured to enclose multiple substrates for simultaneous implantation.