CLAIMS

What is claimed is:

1. An ionization chamber chip for a nano-aperture ion source, the ionization chamber chip comprising:

a first substrate comprising a first depression formed in a back surface thereof;

a backing element attached at the back surface of the first substrate such that a chamber is formed comprising at least the first depression;

a gas inlet formed in the first substrate in fluid communication with the chamber;

a first aperture structure formed in the first substrate in fluid communication with the chamber; and

an electrode layer formed on the back surface of the first substrate, the electrode layer extending into the first depression.

2. The ionization chamber chip of claim 1, wherein the first aperture structure comprises an array of beams formed in a bulk material of the first substrate and an aligned array of aperture holes formed in a material layer forming the back surface of the first substrate.

3. The ionization chamber chip of claim 2, wherein the backing element comprises an array of aperture holes formed therein and aligned with the aperture holes formed in the material layer.

4. The ionization chamber chip of claim 1, further comprising pillars formed on the back surface of the first substrate configured to reduce deformation of the sheet in the region adjacent the first aperture structure, wherein the pillars are formed as at least one selected from a group consisting of one integral layer etched down into the back surface of the first substrate and one integral layer patterned in a high-resolution resist.

5. The ionization chamber chip of claim 1, comprising an array of secondary electron emitters disposed in the first substrate or in the backing element.

6. The ionization chamber chip of claim 1, wherein the backing element comprises a second substrate comprising a second depression formed in a back surface of the second substrate, wherein the back surface of the first substrate and the back surface of the second substrate are attached such that the chamber includes the adjoining first depression and the second depression.

7. The ionization chamber chip of claim 6, wherein the first aperture structure and a second aperture structure formed in the second substrate form a double aperture structure extending through respective thicknesses of the first substrate and the second substrate, the double aperture structure in fluid communication with the chamber.

8. The ionization chamber chip of claim 6, further comprising

a first electrode layer formed on a front surface of the first substrate opposite to the back surface of the first substrate; and

a second electrode layer formed on a front surface of the second substrate opposite to the back surface of the second substrate.

9. The ionization chamber chip of claim 8, wherein the first electrode layer extends at least partially along a wall of the gas inlet and a wall of the double aperture and wherein the second electrode layer extends at least partially along the wall of the double aperture.

10. The ionization chamber chip of claim 9, wherein the gas inlet comprises an inlet aperture extending through the thickness of the first substrate and wherein the second substrate includes a filled depression at a corresponding lateral position to the inlet aperture relative to the attached back surfaces.

11. A nano-aperture ion source, the nano-aperture ion source comprising the ionization chamber chip of claim 1.

12. A method of fabricating an ionization chamber chip for a nano-aperture ion source, the method comprising the steps of:

providing a first substrate comprising a first depression formed in a back surface thereof;

providing a backing element attached at the back surface of the first substrate such that a chamber is formed comprising at least the first depression;

forming a gas inlet in the first substrate in fluid communication with the chamber; and

forming a first aperture structure in the first substrate in fluid communication with the chamber;

wherein the backing element includes a second substrate including a second depression formed in a back surface of the second substrate, wherein the back surface of the first substrate and the back surface of the second substrate are attached such that the chamber includes the adjoining first depression and the second depression.

13. The method as claimed in claim 12, further comprising

forming a first electrode layer on a front surface of the first substrate opposite to the back surface; and

forming a second electrode layer on a front surface of the second substrate opposite to the back surface.

14. The method as claimed in claim 12, wherein the first and second substrates are batch processed prior to being attached to each other.

15. The method as claimed in claim 14, wherein the batch processing includes simultaneously forming respective portions of a double aperture in the first substrate and the second substrate, the double aperture extending through respective thicknesses of the first substrate and the second substrate and in fluid communication with the chamber.

16. The method as claimed in claim 14, wherein the batch processing comprises simultaneously forming a portion of the gas inlet and a corresponding depression in the first and second substrates, respectively.

17. The method as claimed in claims 14, wherein the batch processing includes simultaneously forming a first electrode layer on a front surface of the first substrate opposite to the back surface of the first substrate and a second electrode layer on a front surface of the second substrate opposite to the back surface of the second substrate.

18. An ionization chamber chip for a nano-aperture ion source, the ionization chamber chip comprising:

a first substrate including a first depression formed in a back surface of the first substrate;

a backing element attached at the back surface of the first substrate such that a chamber is formed including at least the first depression;

a gas inlet formed in the first substrate in fluid communication with the chamber; and

a first aperture structure formed in the first substrate in fluid communication with the chamber;

wherein the backing element includes a second substrate including a second depression formed in a back surface of the second substrate, wherein the back surface of the first substrate and the back surface of the second substrate are attached such that the chamber includes the adjoining first depression and the second depression.

19. The ionization chamber chip of claim 18, wherein a second aperture structure formed in the second substrate includes an array of beams formed in a bulk material of the second

substrate and an aligned array of aperture holes formed in a material layer forming the back surface of the second substrate.

20. The ionization chamber chip of claim 18, further comprising:

a first electrode layer formed on a front surface of the first substrate opposite to the back surface of the first substrate; and

a second electrode layer formed on a front surface of the second substrate opposite to the back surface of the second substrate.