Claims

1. An Atomic Layer Process Printer (100) for material deposition, etching and/or cleaning on an atomic scale in a selective area, the printer (100) comprising:
    - a substrate plate (160) for holding a substrate (162) where onto one or more fluids (132, 134) are deposable using the printer (100);
    - a printer head (101) positioned opposite the substrate (162) on the substrate plate (160), wherein the printer head (101) comprises a printer head plate (104) with a number of openings including:
        - one or more first exit openings (112) each having a first exit opening diameter ~~being smaller than~~ in a range of 0.005-900 micro meters;
        - one or more second exit openings (114);
        - one or more third exit openings (116);
        - one or more exhaust openings (118, 120);

    wherein the printer head (101) further comprises a printer head body (102) with:
    - a first inlet supply channel (122) connected to the one or more first exit openings (112) for guiding a first precursor fluid (132) onto the substrate (162) through the one or more first exit openings (112);
    - a second inlet supply channel (124) connected to the one or more second exit openings (114) for guiding a second precursor fluid (134) onto the substrate (162) through the one or more second exit openings (114);
    - a third inlet supply channel (126) connected to the one or more third exit openings (116) for guiding an inert fluid (136) onto the substrate (162) through the one or more third exit openings (116);
    - one or more outlet channels (128, 130) connected to the one or more exhaust openings (118, 120) for removing non-deposited first precursor fluid (132), non-deposited second precursor fluid (134), and inert fluid (136) from the substrate (162);

    wherein the substrate plate (160) is movable in relation to the printer head (101):
    - along an axis in an X,Y plane defined by an X axis and an Y axis being perpendicular in relation to each other;

- along a Z axis being perpendicular to the X,Y plane; and
- at a first angle φ defining a rotation of the X,Y plane around the Z axis;

wherein the substrate plate (160) and the printer head (101) are movable in relation to each other at a second angle θ defining a tilting of the X,Y plane around an axis in the X,Y plane,

wherein the one or more exhaust openings include:

- one or more first exhaust openings (118) connected to a first outlet channel (128) for removing non-deposited first precursor fluid (132), and possibly inert fluid (136), from the substrate (162); and
- one or more second exhaust openings (120) connected to a second outlet channel (130) for removing non-deposited second precursor fluid (134), and possibly inert fluid (136), from the substrate (162).

2. The Printer according to claim 1, wherein the printer head (101) is stationary in the X, Y plane and along the Z axis, wherein the X,Y plane is extending in parallel with the substrate plate (160), wherein the rotation of the X,Y plane around the Z axis is a rotation of the substrate plate (160).

3. The Printer according to any preceding claim, wherein the tilting of the X,Y plane is a tilting of the substrate plate (160) in relation to the printer head (101), and/or wherein the printer head (101) is tiltable.

4. The Printer according to any preceding claim, wherein the second angle (θ) is in the range of 0.5-10 degrees.

5. The Printer according to any preceding claim, wherein the Z axis extends between the printer head (101) and the substrate plate (160) defining a distance between the printer head (101) and the substrate plate (160), wherein the distance between the printer head (101) and the substrate plate (160) is in a range of 0.005-100 µm.

6. The Printer according to any preceding claim, wherein the outlet surface of the printer head (101) further comprises a safety evacuation channel positioned

outermost around the first, second, and third exit openings (112, 114, 116) and the exhaust openings (118, 120).

7. The Printer according to any preceding claim, wherein the printer head (101) outlet surface is in the form of a disc, a square, a rectangle, a triangle, a pentangle, or similar ~~with the sets of opening each forms a circular discs~~.

8. The Printer according to any preceding claim, the Z axis extends between the printer head (101) and the substrate plate (160) defining a distance between the printer head (101) and the substrate plate (160), and wherein the printer is adapted for varying the distance between the printer head (101) and the substrate plate (160) during printing of a three-dimensional structure.

9. The Printer according to any preceding claim, wherein the printer is adapted for operating at a deposition speed of 1 nm/min or below, or at a deposition speed in a range of 0.1-100 nm/min.

10. The Printer according to any preceding claim, wherein the printer is adapted for operating at atmospheric pressure, at vacuum or at ultra-high vacuum.

11. The Printer according to any preceding claim, wherein the printer is adapted for controlling a temperature of the printer head (101) and/or the supply channels (122, 124, 126).

12. The Printer according to any preceding claim, wherein the printer comprises a heating/cooling source heating at least the printer head (101) to allow for it to operate at temperatures between 10-600°C.

13. The Printer according to any preceding claim, wherein the printer is adapted for providing a pattern resolution of 20 nm - 1 mm.

14. The Printer according to any preceding claim, wherein the printer head plate (104) further comprises:

- one or more first distribution channels (142) adapted for guiding the first precursor fluid (132) from the first inlet supply channel (122) to the one or more first exit openings (112);
- one or more second distribution channels (144) adapted for distributing the second precursor fluid (134) from the second inlet supply channel (124) to the one or more second exit openings (114);
- one or more third distribution channels (146) adapted for distributing the inert fluid (136) from the third inlet supply channel (126) to the one or more third exit openings (116).

15. The Printer according to any preceding claim, wherein the printer head plate (104) is removably attached to the printer head (101) such that different printer head plates (104) can be connected to the printer head (101), the different printer head plates (104) having varying sizes of the opening diameter of the first exit opening.

16. The Printer according to any preceding claim, wherein the one or more second and third exit openings (114, 116) and the one or more exhaust openings (118, 120) are positioned in one or more of the following positions:
    - around the one or more first exit openings (112):
    - circumferentially around each of the one or more first exit openings (112); and
    - symmetrically around the one or more first precursors openings.

17. The Printer according to any preceding claim, wherein:
    - a primary set of exhaust openings (118, 120) is positioned between each of the first exit openings (112) and a primary set of second exit openings (114); and/or
    - a primary set of third exit openings (116) is positioned between each of the first exit openings (112) and a primary set of second exit openings (114),

wherein there is a precursor fluid distance between the one or more first exit openings (112) and the primary set of second exit openings (114) being between 5 µm and 3,000 µm.

18. Method for material deposition on a substrate (162) in a selective area, the method comprising the steps of:

- providing an atomic layer process printer with a substrate plate (160) and a printer head (101) positioned opposite each other,
  wherein the substrate plate (160) is movable in relation to the printer head (101):
  - along an axis in an X,Y plane defined by an X axis and an Y axis being perpendicular in relation to each other;
  - along a Z axis being perpendicular to the X,Y plane; and
  - at a first angle φ defining a rotation of the X,Y plane around the Z axis; and

  wherein the substrate plate (160) and the printer head (101) are movable in relation to each other in a second angle θ defining a tilting of the X,Y plane around an axis in the X,Y plane;
- positioning a substrate (162) on the substrate plate (160);

wherein the method further comprises further the steps of sub-method A), or sub-method B),

wherein sub-method A) comprises the steps:

- exposing the substrate (162) to a first precursor fluid (132) through one or more first exit openings (112) each having a diameter <u>in a range of 0.005</u>-~~smaller than~~ 900 micro meters;
- removing the first precursor fluid (132) not deposited on the substrate (162) by means of one or more exhaust openings (118, 120) in combination with exposing the substrate (162) to an inert fluid (136);
- exposing the substrate (162) with the first precursor deposited thereon to a second precursor fluid (134);
- removing the second precursor fluid (134) not deposited on the substrate (162) by means of the one or more exhaust openings (118, 120) in combination with exposing the substrate (162) to an inert fluid (136),

wherein sub-method B) comprises the steps:

- exposing the substrate (162) to a first precursor fluid (132) through one or more first exit openings (112) each having a diameter in a range of 0.005-~~smaller than~~ 900 micro meters;
- removing the first precursor fluid (132) not deposited on the substrate (162) by means of one or more exhaust openings (118, 120) in combination with exposing the substrate (162) to an inert fluid (136) through the one or more first exit openings (112);
- exposing the substrate (162) with the first precursor deposited thereon to a second precursor fluid (134) through the one or more first exit openings (112);
- removing the second precursor fluid (134) not deposited on the substrate (162) by means of the one or more exhaust openings (118, 120) in combination with exposing the substrate (162) to an inert fluid (136) through the one or more first exit openings (112).

19. The method according to claim 18 further comprising the step of:
    - moving the substrate plate (160) and the printer head (101) in relation to each other between the depositing of the precursor fluids (132, 134), and/or
    - moving the substrate plate (160) and the printer head (101) in relation to each other at any direction and repeating the steps of claim 18.

20. Method according to claim 18 or 19, wherein the rotation of the X, Y plane around the Z axis is a rotation of the substrate plate (160), wherein the tilting of the X,Y plane is a tilting of the substrate plate (160) in relation to the printer head (101), and wherein the Z axis extends between the printer head (101) and the substrate plate (160) defining a distance between the printer head (101) and the substrate plate (160),
wherein the printer head (101) comprises a printer head plate (104) with a number of openings including:
    - the one or more first exit openings (112) each having the first exit opening diameter being smaller than 500 micro meters;
    - one or more second exit openings (114);
    - one or more third exit openings (116);

- one or more exhaust openings (118, 120),

wherein the printer head (101) further comprises a printer head body (102) with:

- a first inlet supply channel (122) connected to the first exit opening (112) for guiding the first precursor fluid (132) / the first etching agent onto the substrate (162) through the one or more first exit openings (112);
- a second inlet supply channel (124) connected to the one or more second exit openings (114) for guiding the second precursor fluid (134) / the second etching agent onto the substrate (162) through the one or more second exit openings (114);
- a third inlet supply channel (126) connected to the one or more third exit openings (116) for guiding the inert fluid (136) onto the substrate (162) through the one or more third exit openings (116);
- one or more outlet channels (128, 130) connected to the one or more exhaust openings (118, 120) for removing non-deposited first precursor fluid (132) / first etching agent, non-deposited second precursor fluid (134) / second etching agent, and inert fluid (136) from substrate (162).