**CLAIMS**

1. A method of processing a substrate, comprising:

positioning the substrate in a first processing chamber comprising a first processing volume, the substrate comprising a channel structure having an aspect ratio greater than 20:1;

exposing a silicon-containing layer of the channel structure to a hydrogen-or-deuterium plasma in the first processing volume at a flow rate of 10 sccm to 5000 sccm, the substrate maintained at a first temperature of 100°C to 1100°C during the exposing, the exposing forming a nucleated substrate; and

subsequent to the exposing, performing a thermal anneal operation on the substrate at a second temperature lower than the first temperature by 5% to 50%,

wherein the silicon-containing layer is a polysilicon-containing layer or an amorphous silicon-containing layer.

2. The method of claim 1, wherein the hydrogen-or-deuterium plasma is formed from a hydrogen-or-deuterium containing gas in a remote plasma source.

3. The method of claim 2, wherein:

the hydrogen-or-deuterium containing gas comprises a He, Ne, Ar, Kr, Xe, $N_2$, or a combination thereof; and

$H_2$, $D_2$, $NH_3$, or a combination thereof.

4. The method of claim 1, further comprising positioning the nucleated substrate in a second processing chamber comprising a second processing volume; and

performing the thermal anneal operation on the substrate.

5. The method of claim 4, wherein performing the thermal anneal operation comprises a temperature of 400 °C to 1100 °C for 10 minutes to 2 hours, at a pressure of 1 Torr to 3800 Torr.

6. The method of claim 1, exposing the silicon-containing layer to the hydrogen-or-deuterium plasma in the first processing volume comprises flowing the hydrogen-or-deuterium plasma into the first processing volume at a flow rate of 100 sccm to 1500 sccm.

7. The method of claim 1, wherein the exposing the substrate in the first processing volume occurs for 1 minute to 30 minutes, at a pressure of 10 mTorr to 530 Torr.

8. The method of claim 1, wherein the hydrogen-or-deuterium plasma is formed using an inductively coupled plasma source.

9. A system comprising an algorithm stored in a memory of the system, wherein the algorithm comprises a number of instructions which, when executed by a processor, causes the method of claim 1 to be performed.

10. A method of making a memory device on a substrate comprising:

forming a channel structure in a film stack by etching a channel in the film stack and placing a channel layer at a bottom and in an inner surface of the channel, the channel structure in the film stack having aspect ratios greater than 20:1;

exposing the channel structure with hydrogen radicals in a first processing volume of a first processing chamber;

heating the channel structure at a first temperature of 100 °C to 1100 °C; and

heating the channel structure at a second temperature lower than the first temperature by 5 % to 50% in a second processing volume,

wherein the channel layer is an amorphous layer or a polycrystalline layer.

11. The method of claim 10, wherein exposing the channel structure to hydrogen radicals and heating the channel structure comprises heating the channel structure in the first processing volume at a temperature of 400 °C to 1100 °C for 1 minute to 30 minutes.

12. The method of claim 10, wherein the film stack is a 3D NAND film stack, and the channel layer is an amorphous or polycrystalline layer comprising from 0 wt. % to 100 wt. % of silicon and 0 wt. % to 100 wt. % of a group III, IV and V element.

13. The method of claim 10, further comprising forming the film stack, wherein forming the film stack comprises depositing alternating oxide layers and nitride layers, or alternating oxide layers and polysilicon layers.

14. A method of processing a substrate comprising:

forming an amorphous silicon-containing layer over a bottom and inner surface of a channel formed in a film stack of the substrate, the film stack comprising alternating oxide and nitride layers (ON) or of alternating oxide and polysilicon layers (OP);

exposing the amorphous silicon-containing layer to hydrogen radicals;

heating the substrate at a first temperature of 100°C to 1100°C to form a nucleated silicon-containing layer of the substrate; and

heating the nucleated silicon-containing layer at a second temperature lower than the first temperature by 5% to 50%.

15. The method of claim 14, wherein the silicon-containing layer and channel of the substrate form high aspect ratio features having aspect ratios greater than 20:1.

16. The method of claim 14, wherein the substrate is heated at the first temperature in a first process volume of a first process chamber and the nucleated silicon-containing layer of the substrate is heated to the second temperature in a second process volume of a second process chamber.

17. The method of claim 16, wherein a flow rate of the hydrogen radicals into the first process volume is from 10 sccm to 5000 sccm.

18. The method of claim 16, further comprising heating the substrate in the first process volume at a temperature of 400°C to 1100°C, for 1 minute to 30 minutes.

19. The method of claim 14, further comprising heating the nucleated silicon-containing layer of the substrate at a temperature of 400 °C to 1100 °C for 10 minutes to 2 hours and a pressure of 1 Torr to 3800 Torr.