However, the repetitive provision of alternating fluxes is very time consuming and the effort to create the ultra-high vacuum necessary for the MBE process is very high. To achieve this pressure, which is less than 10^{-12} of atmospheric pressure, one needs several vacuum pumps and a long time to pump down. Furthermore, only one wafer can be processed simultaneously and the growth is only about 1 micron per hour.

Therefore, further methods, with which an aluminium nitride layer can be deposited on silicon substrates, are desirable.

A method for depositing an aluminium nitride semiconductor layer on a silicon substrate is provided that comprises providing a silicon substrate; placing the substrate in a vacuum chamber; conditioning a surface of the substrate by etching and providing a conditioned surface; heating the substrate to a temperature T_1; depositing an aluminium film onto the conditioned surface of the substrate by a sputtering method under an atmosphere of Argon and depositing an epitaxial aluminium nitride layer on the aluminium film by a sputtering method under an atmosphere of Nitrogen and Argon.

The combination of an etching process to provide a conditioned surface and depositing an aluminium film onto this conditioned surface has been found to facilitate the formation of a essentially Al-terminated silicon substrate. One possible mechanism, by which this feature may be provided, may lie in the formation of an Al-terminated conditioned structure after the etching step which encourages the formation of a N-face polarity aluminium nitride semiconductor layer deposited onto this Al-terminated substrate surface.

Claims

1. A method for depositing an aluminium nitride layer on a silicon substrate, comprising:

providing a silicon substrate;

placing the substrate in a vacuum chamber;

conditioning a surface of the substrate by etching and providing a conditioned surface;

heating the substrate to a temperature T_1;

depositing an aluminium film onto the conditioned surface of the substrate by a sputtering method under an atmosphere of Argon; and

depositing an epitaxial aluminium nitride layer on the aluminum film by a sputtering method under an atmosphere of Nitrogen and Argon ~~Argon.~~

~~2. The method according to claim 1~~, wherein the conditioning the surface of the substrate comprises plasma soft-etching the surface under vacuum~~.~~

~~3. The method according to claim 2~~, and wherein the plasma soft-etching comprises heating the substrate to a temperature T_2, introducing Ar gas into the vacuum chamber and subjecting the surface of the substrate to a plasma~~.~~

~~4. The method according to claim 3~~, wherein T_2 is 35°C to 70°C~~.~~

~~5. The method according to one of claims 2 to 4~~, and wherein the plasma soft-etching is carried out at a pressure of 2.10^{-4} mbar to 8.10^{-4} mbar with a RF plasma comprising Ar^+ ions.

26. The method according to ~~one of~~ claims ~~2 to 5~~1, wherein $T_2 < T_1$.

37. The method according to ~~one of~~ claims 1 or ~~2 to 6~~, wherein the providing of the silicon substrate includes the providing of a <111> silicon substrate.

~~8. The method according to claim 1, wherein the conditioning the surface of the substrate comprises chemical etching the surface.~~

49. The method according to one of claims 1 to 38, wherein the etching comprises preferentially removing chemically bound oxygen from the substrate.

510. The method according to one of claims 1 to 49, wherein after the depositing of the aluminium film the surface is mainly Al-terminated.

611. The method according to one of claims 1 to 510, further comprising subjecting the conditioned surface to a hydrogen cntaining gas flow in the vacuum chamber after the conditioning.

712. The method according to one of claims 1 to 58, wherein T_1 lies in the range 650°C to 800°C.

813. The method according to one of claims 1 to 712, further comprising flowing Argon gas over the substrate whilst the substrate is heated up to the temperature T_1.

914. The method according to one of claims 1 to 813, wherein the conditioning is carried out in a first vacuum chamber and the depositing is carried out in a second vacuum chamber.

1015. The method according to one of claims 1 to 914, further comprising reducing the pressure in the vacuum chamber after the conditioning.

1116. The method according to one of claims 1 to 1015, wherein the aluminium ~~nitride~~ film is deposited onto the conditioned surface of the substrate by ~~reactive~~ DC sputtering.

1217. The method according to claim 1116, wherein a DC power of approximately 100 W is used to sputter the aluminium film onto the conditioned surface.

1318. The method according to one of claims 1 to 1217, wherein the aluminium nitride layer is deposited onto the aluminium film by reactive sputtering.

1419. The method according to claim 1318, wherein a DC power of approximately 1.0 to 3 kW is used to sputter the aluminium nitride layer onto the aluminium film.

1520. The method according to one of claims 1 to 1419, further comprising actively cooling the substrate after depositing the aluminium nitride layer.