CLAIMS

1. A method of depositing a graphene layer on a substrate, comprising:

providing a substrate within a modular microwave plasma chamber, the substrate comprising a titanium nitride surface;

pretreating the substrate with a plasma treatment in the modular microwave plasma chamber to remove an oxide from the titanium nitride surface of the substrate;

subsequent to pretreating the substrate, without removing the substrate from the modular microwave plasma chamber, flowing a carbon source and a hydrogen source into the modular microwave plasma chamber;

subsequent to flowing the carbon source and the hydrogen source, without removing the substrate from the modular microwave plasma chamber, striking a plasma in the modular microwave plasma chamber, wherein a substrate temperature is below approximately 400 °C; and

subsequent to striking the plasma, without removing the substrate from the modular microwave plasma chamber, depositing the graphene layer on the titanium nitride surface of the substrate in the modular microwave plasma chamber.

2. The method of claim 1, wherein the graphene layer is substantially a single sheet of graphene.

3. The method of claim 1, wherein the graphene layer comprises a plurality of sheets of graphene stacked over each other.

4. The method of claim 1, wherein the substrate temperature is below approximately 100 °C.

5. The method of claim 1, wherein a laser Raman spectrum of the graphene layer comprises an I_D/I_G ratio that is approximately 1.0 or smaller.

6. The method of claim 1, wherein a laser Raman spectrum of the graphene layer comprises an I_{2D}/I_G ratio that is approximately 1.0 or greater.

7. The method of claim 1, further comprising:

flowing an inert gas into the modular microwave plasma chamber during the flowing of the carbon source and the hydrogen source into the modular microwave plasma chamber.

8. A method of depositing a graphene layer on a substrate, comprising:

providing a substrate in a modular microwave plasma chamber, wherein the modular microwave plasma chamber comprises:

a chamber;

a dielectric chamber lid;

a plurality of microwave applicators coupled to the dielectric chamber lid, wherein the plurality of microwave applicators sit in recesses into the dielectric chamber lid; and

a plurality of solid state microwave emission modules, wherein each solid state microwave emission module is coupled to one of the plurality of microwave applicators;

pretreating the substrate with a plasma treatment in the modular microwave plasma chamber to remove an oxide from a titanium nitride surface of the substrate;

subsequent to pretreating the substrate, without removing the substrate from the modular microwave plasma chamber, flowing a carbon source and a hydrogen source into the modular microwave plasma chamber;

subsequent to flowing the carbon source and the hydrogen source, without removing the substrate from the modular microwave plasma chamber, striking a plasma in the modular microwave plasma chamber by applying microwave power to a plurality of antennae that are laterally separated from each other, wherein a substrate temperature is below approximately 400 °C; and

subsequent to striking the plasma, without removing the substrate from the modular microwave plasma chamber, depositing the graphene layer on the titanium nitride surface of the substrate in the modular microwave plasma chamber.

9. The method of claim 8, wherein a diameter of the recesses is greater than a diameter of the microwave applicators.

10. The method of claim 9, wherein dielectric bodies of the microwave applicators are a monolithic part with the dielectric chamber lid.

11. The method of claim 8, wherein the substrate temperature is below approximately 100 °C.

12. The method of claim 8, wherein a distance between the dielectric chamber lid and the substrate is approximately 4 cm or less.

13. A method of depositing a graphene layer on a substrate, comprising:

providing a substrate within a modular microwave plasma chamber, the substrate comprising a titanium nitride surface;

treating a surface of the substrate with a first plasma process in the modular microwave plasma chamber to remove an oxide from the titanium nitride surface of the substrate;

subsequent to treating the surface of the substrate, without removing the substrate from the modular microwave plasma chamber, initiating a second plasma process that comprises flowing a carbon source and a hydrogen source into the modular microwave plasma chamber, and subsequent to flowing the carbon source and the hydrogen source, without removing the substrate from the modular microwave plasma chamber, striking a plasma in the modular microwave plasma chamber, wherein a substrate temperature is below approximately 400 °C; and

subsequent to striking the plasma, without removing the substrate from the modular microwave plasma chamber, depositing the graphene layer on the titanium nitride surface of the substrate in the modular microwave plasma chamber, wherein a laser Raman spectrum of the graphene layer comprises an I_D/I_G ratio that is approximately 1.0 or smaller, and wherein the laser Raman spectrum of the graphene layer comprises an I_{2D}/I_G ratio that is approximately 1.0 or greater.

14. The method of claim 13, wherein the substrate temperature is below approximately 100 °C.