CLAIMS

1. A method of depositing graphene on a metal surface of a substrate, the method comprising:

providing a substrate in a reaction chamber, wherein the substrate includes a metal surface;

flowing one or more hydrocarbon precursors into the reaction chamber and toward the substrate;

generating, from a hydrogen source gas, radicals of hydrogen in a remote plasma source that is positioned upstream of the one or more hydrocarbon precursors; and

introducing the radicals of hydrogen into the reaction chamber and toward the substrate, wherein the radicals of hydrogen react with the one or more hydrocarbon precursors to deposit graphene on the metal surface of the substrate.

2. The method of claim 1, wherein each of the one or more hydrocarbon precursors includes an alkene or alkyne group.

3. The method of claim 2, wherein each of the one or more hydrocarbon precursors includes toluene, benzene, ethylene, propylene, butene, pentene, pentadiene, hexene, acetylene, propyne, butyne, or pentyne.

4. The method of claim 1, wherein all or substantially all of the radicals of hydrogen in an environment adjacent to the substrate are radicals of hydrogen in a ground state.

5. The method of claim 1, wherein the substrate is maintained at a temperature between 200°C and 400°C during deposition of graphene on the metal surface of the substrate.

6. The method of claim 1, further comprising:

treating the metal surface of the substrate prior to depositing graphene on the metal surface, wherein treating the metal surface includes exposing the metal surface to a plasma of a reducing gas species.

7. The method of claim 6, wherein treating the metal surface further includes exposing the metal surface to a cyano-based radical species.

8. The method of claim 7, wherein treating the metal surface further includes generating, from at least a carbon-containing source gas and a nitrogen-containing source gas, a plasma containing the cyano-based radical species, wherein exposing the metal surface to the cyano-based radical species occurs before or after exposing the metal surface to the plasma of the reducing gas species.

9. The method of claim 7, wherein exposing the metal surface to the cyano-based radical species occurs simultaneous with exposing the metal surface to the plasma of the reducing gas species, wherein the cyano-based radical species is generated by exposing a downstream carbon-containing precursor having a cyano group to the plasma of the reducing gas species, wherein the plasma of the reducing gas species is generated in a remote plasma source that is positioned upstream of the downstream carbon-containing precursor.

10. The method of claim 7, wherein the plasma of the reducing gas species is a plasma of a reducing gas species and of a nitrogen-containing agent, wherein exposing the metal surface to the cyano-based radical species occurs simultaneous with exposing the metal surface to the plasma of the reducing gas species and of the nitrogen-containing agent, wherein the cyano-based radical species is generated by exposing a downstream carbon-containing precursor to the plasma of the reducing gas species, wherein the plasma of the reducing gas species and of the nitrogen-containing agent is generated in a remote plasma source that is positioned upstream of the downstream carbon-containing precursor.

11. The method of claim 1, wherein the metal surface includes copper, ruthenium, nickel, molybdenum, cobalt, or combinations thereof.

12. The method of claim 1, wherein the substrate is a semiconductor wafer or semiconducting workpiece, wherein the metal surface of the substrate faces towards the remote plasma source.

13. The method of claim 1, wherein the graphene is deposited under conditions that selectively deposit on a metal of the metal surface of the substrate without

depositing on a dielectric material or other non-metal material.

14. The method of claim 1, further comprising:

annealing the graphene on the metal surface of the substrate at a temperature between 200°C and 400°C.

15. An apparatus for depositing graphene on a metal surface of a substrate, the apparatus comprising:

a reaction chamber;

a substrate support in the reaction chamber and configured to support a substrate, wherein the substrate includes a metal surface;

a remote plasma source upstream of the reaction chamber, wherein the metal surface of the substrate faces towards the remote plasma source;

one or more gas outlets in the reaction chamber and downstream from the remote plasma source; and

a controller configured with instructions for performing the following operations:

flow one or more hydrocarbon precursors through the one or more gas outlets into the reaction chamber and toward the substrate;

generate, from a hydrogen source gas, radicals of hydrogen in the remote plasma source; and

introduce the radicals of hydrogen into the reaction chamber and towards the substrate, wherein the radicals of hydrogen react with the one or more hydrocarbon precursors to deposit graphene on the metal surface of the substrate.