CLAIMS

What is claimed is :

1. A method of forming a semiconductor device structure, comprising:

forming at least one 2D material over a substrate; and

treating the at least one 2D material with laser beams having different frequencies of electromagnetic radiation than one another to selectively energize and remove crystalline defects from the at least one 2D material, the different frequencies of electromagnetic radiation corresponding to different resonant frequencies of the crystalline defects.

2. The method of claim 1, further comprising selecting the at least one 2D material from the group consisting of graphene, graphene-oxide, stanene, phosphorene, hexagonal boron nitride, borophene, silicene, graphyne, germanene, germanane, a 2D supracrystal, a transition metal di-chalcogenide, an MXene, a single atomic layer of a metal material, a single atomic layer of a semi-metal material, and a single atomic layer of a semiconductive material.

3. A method of forming a semiconductor device structure, comprising:

forming a transition metal di-chalcogenide having the general chemical formula MX_2 over a substrate, where M is Mo, W, Nb, Zr, Hf, Re, Pt, Ti, Ta, V, Co, Cd, or Cr, and where X is O, S, Se, or Te; and

treating the transition metal dichalcogenide with at least one laser beam having a frequency of electromagnetic radiation corresponding to a resonant frequency of crystalline defects within the transition metal dichalcogenide to selectively energize and remove the crystalline defects from the transition metal dichalcogenide.

4. The method of claim 1, wherein forming at least one 2D material over a substrate comprises forming only one 2D material over the substrate.

5. A method of forming a semiconductor device structure, comprising:

forming a stack of different 2D materials over a substrate; and

treating the stack of different 2D materials with at least one laser beam having a frequency of electromagnetic radiation corresponding to a resonant frequency of crystalline defects within the stack of different 2D materials to selectively energize and remove the crystalline defects from the stack of different 2D materials.

6. The method of claim 1, wherein treating the at least one 2D material with laser beams having different frequencies of electromagnetic radiation than one another comprises exposing the at least one 2D material to at least one of the laser beams after exposing the at least one 2D material to at least one other of the laser beams.

7. The method of claim 1, wherein treating the at least one 2D material with laser beams comprises simultaneously treating the at least one 2D material with at least two of the laser beams.

8. A method of forming a semiconductor device structure, comprising:
forming at least one 2D material over a substrate;
thermally annealing the at least one 2D material; and
treating the at least one 2D material with at least one laser beam having a frequency of electromagnetic radiation corresponding to a resonant frequency of crystalline defects within the at least one 2D material to selectively energize and remove the crystalline defects from the at least one 2D material.

9. The method of claim 8, wherein thermally annealing the at least one 2D material comprises thermally annealing the at least one 2D material prior to treating the at least one 2D material with the at least one laser beam.

10. The method of claim 8, wherein thermally annealing the at least one 2D material comprises thermally annealing the at least one 2D material after treating the at least one 2D material with the at least one laser beam.

11. The method of claim 8, wherein thermally annealing the at least one 2D material comprises thermally annealing the at least one 2D material while simultaneously treating the at least one 2D material with the at least one laser beam.

12. The method of claim 1, further comprising subjecting the at least one 2D material to a remote plasma treatment process.

13. A method of forming a semiconductor device structure, comprising:

subjecting a 2D material on a substrate to a laser treatment process to reduce a crystalline defect density of the 2D material, the laser treatment process comprising exposing the 2D material to at least one frequency of electromagnetic radiation substantially the same as at least one resonant frequency of crystalline-defect-free and crystalline-defect-laden forms of the 2D material where resonant peak intensities of the crystalline-defect-free and crystalline-defect-laden forms of the 2D material are different than one another.

14. The method of claim 13, wherein subjecting the 2D material to a laser treatment process comprises subjecting the 2D material to the laser treatment process during the formation of the 2D material on the substrate.

15. The method of claim 13, wherein subjecting the 2D material to a laser treatment process comprises subjecting the 2D material to the laser treatment process after forming the 2D material on the substrate.

16. The method of claim 13, further comprising subjecting the 2D material to a thermal annealing process to raise a ground state of all atoms and crystalline defects within the 2D material and increase a rate of diffusion of the crystalline defects out of the 2D material.

17. The method of claim 16, wherein subjecting the 2D material to a thermal annealing process comprises subjecting the 2D material to the thermal annealing process before subjecting the 2D material to the laser treatment process.

18. The method of claim 16, wherein subjecting the 2D material to a thermal annealing process comprises simultaneously subjecting the 2D material to the thermal annealing process and the laser treatment process.