Claims

1. An adhesive-free method of transferring a thin film from a first substrate to a second substrate comprising the steps of:
   (a) providing a transfer structure, wherein the transfer structure comprises a support layer and a film contact layer, and wherein the support layer comprises an elastomer and has a Young's modulus of 300 kPa-10 MPa, the elastomer being selected from a group consisting of: poly(dimethylsiloxane), polyurethane, butadiene-acrylonitrile copolymer, perfluoroalkoxy polymers, polyethylene, poly(ethyl acrylate), polyisoprene, polybutadiene, polychloropene, and combinations thereof;
   (b) providing a thin film on a surface of a first substrate;
   (c) contacting the film contact layer of the transfer structure with the thin film;
   (d) removing the first substrate to obtain the transfer structure with the thin film in contact with the film contact layer;
   (e) supporting the thin film on the film contact layer with the support layer which the thin film is in contact with the film contact layer after step (d) and prior to step (f);
   (f) contacting the transfer structure after step (e) with a surface of a second substrate;
   (g) removing the film contact layer and the support layer, wherein the removing comprises dissolving the film contact layer; and
   (h) obtaining the thin film on the surface of the second substrate after step (g), wherein steps (a) through (h) are performed without use of adhesives.

2. The method according to claim 1, wherein the thin film is one or more film with each film having a thickness of an atomic, molecular, or ionic layer.

3. The method according to claim 1, wherein the support layer is released before or during the removing of the film contact layer.

4. The method according to claim 1, wherein the thin film is selected from a group consisting of: graphene, boron nitride (BN), molybdenum disulfide (MoS_2), molybdenum-sulphur-iodine (MoSI), molybdenum (V) telluride ($MoTe_2$), niobium (IV)

telluride ($NbTe_2$), nickel selenide ($NiSe_2$), tungsten disulfide (WS_2), copper (Cu), gold (Au), silver (Ag), platinum (Pt), palladium (Pd), silicon (Si), gallium arsenide (GaAs), indium gallium arsenide (InGaAs), copper indium gallium arsenide, yttrium barium copper oxide, strontium titanate ($SrTiO_3$), cadmium telluride (CdTe), gallium indium phosphide (GaInP), alumina (Al_2O_3), and combinations thereof.

5. The method according to claim 1, wherein the thin film is patterned.

6. The method according to claim 5, wherein the support layer is patterned.

7. The method according to claim 1, wherein the support layer has a thickness of 100 μm – 10 mm.

8. The method according to claim 1, wherein the film contact layer comprises a polymer.

9. The method according to claim 8, wherein the polymer is selected from a group consisting of: polystyrene, polycarbonate, poly(methyl methacrylate), polydimethylsiloxane, polyisobutylene, divinylsiloxane-bis-benzocyclobutene resin, poly(styrene sulfonic acid), polyacrylic acid, poly(allylamine hydrochloride), polyimide, copolymers of tetrafluoroethylene and 2,2-bistrifluoromethyl-4,5-difluoro-1,3-dioxiole, fluorinated methacrylate polymers, fluoroacrylate polymers, perfluoro(1-butenyl vinyl ether) homocopolymer, and a combination thereof.

10. The method according to claim 1, wherein the film contact layer has a thickness of 10 – 5000 nm.

11. The method according to claim 1, wherein the contact of the thin film with the film contact layer is by van der Waals interaction.

12. The method according to claim 1, wherein the thin film is provided on the surface of the first substrate by electrospinning, spin coating, plating, chemical solution deposition, chemical vapour deposition, plasma-enhanced chemical vapour

deposition, atomic layer deposition, thermal evaporation, electron beam evaporation, molecular beam epitaxy, sputtering, pulsed laser deposition, cathodic arc deposition, electrohydrodynamic deposition, inkjet printing, aerosol spraying, dip coating, drop casting, physical vapour deposition, vacuum sublimation, doctor blading, and a combination thereof.

13. The method according to claim 1, wherein the second substrate is a rigid or flexible substrate.

14. The method according to claim 1, wherein the second substrate is patterned.

15. The method according to claim 1, further comprising a step of patterning the thin film before or after the providing of step (a).

16. The method according to claim 1, wherein the contacting of step (f) comprises applying a pressure of 0.01-8 bar on the transfer structure.

17. The method according to claim 1, wherein the second substrate is comprised in a thin film device.

18. The method according to claim 1, wherein supporting the thin film on the film contact layer with the support layer while the thin film is in contact with the film contact layer comprises preventing stretching or deformation of the thin film.

19. The method according to claim 1, wherein supporting the thin film on the film contact layer with the support layer while the thin film is in contact with the film contact layer comprises preventing mechanical damage to the thin film using the support layer after step (d) and prior to step (f).