CLAIMS

1. A method of embedding a wire in a substrate in a 3D-printing process, the method comprising:

extruding the wire in an extrusion direction via a nozzle towards a substrate surface of the substrate, the wire being pre-heated before being extruded via the nozzle;

forming an anchor by concurrently extruding the wire into the substrate;

concurrently with the extruding of the wire, displacing the nozzle in a pull-away direction away from the substrate surface to form an exposed length of the wire between the anchor at the substrate surface and the nozzle, wherein the exposed length of the wire is formed without the exposed length of the wire between the anchor and the nozzle contacting the substrate surface;

providing a cooling phase, each of the wire and the substrate undergoing unaided cooling in the cooling phase, the cooling phase including a dwelling cooling phase in which the nozzle is spaced apart from the substrate throughout the dwelling cooling phase and in which the exposed length of the wire from the anchor to the nozzle is maintained straight and at an angle between 45 degrees and 90 degrees relative to the substrate surface; and then

forming a surface embedded length of the wire using the exposed length of the wire in a surface embedding phase, wherein the surface embedding phase includes displacing the nozzle to a next nozzle retracting point and towards the substrate surface to angularly displace the exposed length of the wire until the exposed length of the wire comes into contact with the substrate surface and the exposed length of wire forms the surface embedded length of the wire.

2. The method according to claim 1, further comprising:

upon the nozzle being proximal to the substate surface at the next nozzle retracting point, displacing the nozzle in the pull-away direction.

3. The method according to any one of claims 1 to 2, wherein the surface embedded length of the wire is joined to the substrate such that the surface embedded length of the wire is substantially disposed in one embedment layer of the substrate.

4. The method according to any one of claims 1 to 3, wherein the surface embedded length of the wire is joined to the substrate such that the surface embedded length of the wire is substantially parallel to the substrate surface.

5. The method according to any one of claims 1 to 4, wherein the surface embedded length of the wire comprises at least one partially surface embedded part.

6. The method according to any one of claims 1 to 5, wherein the surface embedded length of the wire comprises at least one fully surface embedded part.

7. The method according to any one of claims 1 to 6, wherein the exposed length of the wire is exposed to air on all sides immediately before the forming of the surface embedded length of the wire.

8. The method according to any one of claims 1 to 7, wherein the cooling phase follows the surface embedding phase.

9. The method according to any one of claims 1 to 8, further comprising changing a direction of travel of the nozzle to form a turning point between a first section of a printing path and a second section of the printing path, wherein the first section of the printing path and the second section of the printing path are contiguous and non-parallel to one another.

10. The method according to claim 9, wherein no more than two cooling phases immediately following the turning point comprises a dwelling cooling phase.

11. The method according to any one of claims 1 to 10, further comprising at least one non-dwell cooling phase, wherein the nozzle is not spaced apart from the substrate at a substantially constant nozzle-substrate spacing in the non-dwell cooling phase.

12. The method according to any one of claims 1 to 11, further comprising:

extruding the wire at a non-zero extrusion speed if a nozzle-substrate spacing is concurrently increasing; and

not extruding the wire if the nozzle-substrate spacing is not increasing, wherein the nozzle-substrate spacing corresponds to a spacing between a tip of the nozzle and the substrate surface.