Aerosol Jet Printing

Due to the interests of the aerospace and electronics industries, researchers have developed a relatively new method of printing that uses aerosolized droplets to deposit materials onto the designated surface. The chosen material must be aerosolized into a liquid with small droplets and then sent through a collimated beam. For best accuracy, these droplets typically have diameters that are between two and five microns. Once this process is complete, the beam leaves the aerosol head at about 80 m/s and the droplets land on the designated surface, which is a predetermined substrate. Aerosol jet printing differs from other methods of direct-write printing because there is no contact with the substrate until the droplets are placed; the jet propels the droplets down to the surface using aerodynamics. This methodology allows the device to print on different surfaces while using multiple layers and multiple materials. For example, aerosol jet printing can be used to generate multi-layered circuits [].

Researchers have also found that aerosol jet printing can be used to print on non-planar surfaces, such as surfaces that have slight curvature or topography. This is of interest because additive manufacturing can be used in embedding sensors and antenna onto uneven surfaces such as aircraft fuselages. Using 3D printing for instances such as these decreases the weight of the structure [].

Electrohydrodynamic Printing

Similar to aerosol jet printing, electrohydrodynamic printing generates small droplets of liquid material that are only a few microns in diameter. This system was developed for the primary purpose of manufacturing organic printed electronics. These electronics are made of polymeric composites because they can withstand a substantial level of mechanical deformation. During the process of electrohydrodynamic printing, liquid material is forced through capillary tubing that ends in a small nozzle. The liquid is applied to the designated substrate using the electric force on the ions in the material, which results from the applied electric field in the printer. By modifying the strength of the electric field, researchers were able to alter the size and drip frequency of the droplets [].

When compared to other more complicated methods of 3D printing, electrohydrodynamic printing is easier to use in testing processes. This is due to the fact that the process does not require high temperatures, high pressure, a vacuum, or high-functioning generators. Experiments can be conducted at room temperature and are not affected by changes in humidity.

Although this method has proven to be useful, it does have its downsides. This method may not be useful to print onto uneven surfaces because the distance between the nozzle and the substrate must be within 2-3mm, which would be much more difficult to maintain over a substrate that is not level. In addition, the width of the line that is printed is dependent on the diameter of the droplet of material. Theses sizes can be altered by changing the inner diameter of the nozzle. However, the nozzle can get clogged if the inner diameter is too small or if the chosen material is too dense [].

Fused Deposition Modeling

Fused deposition modeling (FDM) is a more common method of 3D printing that is used to construct models and prototypes. During this additive manufacturing process, the 3D printer constructs a part by building it up with individual layers. The chosen material, typically a type of plastic, is heated and directed onto the surface through the printer’s extruder. The material solidifies to the previous layer after it leaves the extruder. This method of printing is cheaper than many other methods because it requires less expensive materials, and the technology tends to be less complex. However, the trade-off is that this comes with a decrease in the accuracy of the models and prototypes formed using this technique. In addition, the process is more time consuming than other methods of printing [].

Laminated Object Manufacturing

Laminated object manufacturing (LOM) is a process that involves fusing together sheets of plastic materials using high temperatures and pressures. A laser or blade is used to manipulate the materials into the required form after they have been fused together. This method is similar to FDM because the printed objects are formed using layers of material, but the LOM method cuts away excess material in the layers instead of printing the exact shape initially. Due to these differences, objects produced using LOM require additional processes such as sanding or varnish after the printing process is completed. Overall, this often leads to a final product with a lower level of accuracy and it would not be ideal for this research project [].

Selective Laser Sintering

Selective laser sintering (SLS) is the process of fusing small particles of material together using the heat from a high-powered laser beam. Common materials used in this process are glass, ceramics, and plastic. The material is initially formed into a compressed powder bed inside a sealed chamber, and then the laser moves across the bed to trace the design of the object. The powder solidifies into the object and then requires a cool down period before it can be removed from the sealed chamber. This process is advantageous due to the fact that structure support is not necessary, even for complex objects. In addition, the objects produced by this printing method tend to be more durable than more traditional methods of 3D printing, such as FDM. However, the technology required for this process is more expensive than other methods of 3D printing, which makes it a less than ideal choice for this research project [].

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