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2D to 4D: Increasing dimensions of fabrication: A brief review

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Abstract
Traditional method of fabrication involves the conventional process of Subtractive manufacturing. Ant object is made by manually cutting the material generally with CNC machine. The desired shaped material is obtained and rest of the material is discarded. This requires elaborate infrastructure and is a tedious lengthy process. This is being gradually replaced by a contrasting technology of additive manufacturing. It is based on principle of stereo lithography that creates three dimensional printing. More recently, four-dimensional printing is becoming the accepted method of fabrication.

Keywords: additive manufacturing; electro hydrodynamic printing (EHDP); 4D printing; 3D printing; 2D printing

1. Introduction
The basic fabrication technology entails either subtractive or additive manufacturing. Earlier methods adopted carving out the desired pattern by removing the undesirable component while more recent advancements entail purely additive method [1]. Electro hydrodynamic printing facilitates fabrication of specific controlled pattern. However, it permits only two-dimensional (2D) micro patterns. A new dimension has been added through three-dimensional printing introduced by developed by Carl Deckard or Chuck Hall in 1984. The manufacturing is continuously evolving to four-dimensional fabrication.

2. Process
Electro hydrodynamic print (EHDP) is the technology of orderly printing of micro droplets using electro hydro dynamically induced flow of materials [2]. Additive manufacturing technique transforms concept models and prototypes, provides accuracy down to 0.1mm and microscopic layer resolution. It produces the two-dimensional (2D) printing. In 2D printing inkjet printer drops ink onto the paper while in 3D printing printer jets drops of material in layers on to a build tray. Further a tactile dimension is added to 2D printing allowing user to touch and feel the surface and texture of printed object. It adds a small vertical dimension to 2D printing sometimes also called as 2.5D. This is a textured printing or elevated printing.
The fabrication technology evolved and a new vertical dimension was added making it three-dimensional (3D) printing and this 3D printing is growing since 1970s. 3Dprinting refers to process of manufacturing physical objects from digital files (3D models) using 3D printer. It is based on stereo lithography in which layers are added by using photopolymer with UV lasers
More recently, self-assembly has appeared as a paradigm shift in manufacturing technology. A new dimension of time has been included. 4D is 3D printing with an additional dimension of time. Objects created with 4D printing evolve with time. The concept was introduced by Prof Skylar Tiddbits. 4D printing is similar to 3D printing except that it utilizes pre-programmed smart materials with shape memory permitting self-deformation and self-transformation. The difference between 3D and 4D printing lies in the fact that the object can morph over time on energy input/trigger or on their own. With a multi-material print a product can change from 1D strand to 2D surface to 3D shape and change morphology further.
5D is a related term, however, it is not the evolved new dimension in fabrication. No new dimension is added, it is only 3D printing using 5 axis additive manufacturing technique where print bed is capable of moving on two axis in addition of three axis of 3D printer.

3. Materials
Primarily the materials utilized are photopolymers and thermoplastics. Materials are programmable. In 4D printing they get activated by energy input. Objects adapt and change as per need. The transformation needs stimuli. The stimuli may be water, moisture, temperature, pressure, surface change, force change etc. For medical use the materials are biocompatible.
The pre-processing starts with 3D Computer Aided Designing (CAD) file where CAD model digital data is acquired. 3D printing makes a physical transcription of digital data. In the production the 3D printer jets droplets of liquid photopolymer on the build tray and instantly cures the tiny droplets thus forming the fine layer. In case of complex structures with overhangs, a removable support material is used. In the final step removable support material is conveniently removed. No further processing is needed.

4. Benefits
Manufacturing process is changing from hiring labour and space to simple control through a click. The machine operation cost is low, overhead cost is reduced and labor cost is almost zero. The process of 3D and 4D printing is fast. The journey from idea or concept to the item is fast even when complex designs are involved. The technology includes design freedom where complex geometries are easily created. This it shrinks the development process and fastens the delivery. It fabricates accurate parts which are smooth, tough and stable. Even the complex shapes are attainable with precise shapes. It

permits greater creativity and can create virtually anything with repeatable customization.

The scale models and prototypes of larger products to reduced tie to get the first version of the product provide the benefit of verification pre-visualization. The process is sustainable as it produces very less waste unlike subtractive manufacturing. Hence material cost is optimal as no wastage and need to dispose of the waste.

5. Applications

It generally covers almost all of the areas of manufacturing. 3D printing is well integrated in surgical practice and research and 4D printing is catching up. Bio-printing holds mammoth avenues of applications. Potential application ranges from anatomical models for surgical planning to surgical guides and implants [3, 4]. It ranges from medical devices, surgical instruments, dental implants, hearing aids etc [5, 6]. 3D human tissue constructs will offer cost effective cardiovascular tissue equivalents.

6. Conclusion

3D printing is established, however, the traditional manufacturing methods are not going to be replaced completely. 4D printing is following the 3D printing and emerging new age technology. It is a radical shift. It appears to be the game changer in manufacturing field. It holds applications in almost every field as it is quite innovative.4D printing is process of printing customizable smart materials with capability of shape transfer over time.

7. References

1. Zhang B, He J, Li X, Xu F, Li D. Micro/nanoscale electrohydrodynamic printing: from 2D to 3D. Nanoscale. 2016; 8(34):15376-88.
2. Borovjagin AV, Ogle BM, Berry JL, Zhang J. From Microscale Devices to 3D Printing: Advances in Fabrication of 3D Cardiovascular Tissues. Circ Res. 2017; 120(1):150-165.
3. Tack P, Victor J, Gemmel P, Annemans L. 3D-printing techniques in a medical setting: a systematic literature review. Biomed Eng Online. 2016; 15(1):115.
4. Van Noort R. The future of dental devices is digital. Dent Mater. 2012; 28(1):3-12.
5. Farjood E, Hamedani S. Rapid Prototyping Technologies and their Applications in Prosthodontics, a Review of Literature. J Dent (Shiraz). 2015; 16(1):1-9.
6. Conner BP, Manogharan GP, Martof AN, Rodomsky LM, Rodomsky CM, Jordan DC. *et al.* Making sense of 3-D printing: Creating a map of additive manufacturing products and services**.** Additive Manufacturing. 2014; 1:64-76.