*International Journal of Engineering Applied Sciences and Technology, 2020*
**Vol. 5, Issue 5, ISSN No. 2455-2143, Pages 270-273**
Published Online September 2020 in IJEAST (http://www.ijeast.com)

# BIOMEDICAL APPLICATIONS OF ADDITIVE MANUFACTURING

Vigneshwaran T
Department of Manufacturing Engineering
Central Institute of Plastics Engineering and Technology, Chennai, Tamil Nadu, India

***Abstract*— Additive manufacturing a virtue of future is now rapidly implemented in almost all areas of medical professions. 3D printing covers all range sectors that is from surgical operators to pharma people and from dental doctors to Biomedical engineers. The modern technology usage is already started to get revenue as helpful and profitable in medical sector like Foot and ankle-foot orthoses, prosthetics, dental and hearing aids. Though the technology advanced the cost is main issue in manufacturing these devices or implants. This paper reviews about the various new biomedical advancements and the 3D printing devices and methods.**

*Keywords*— **3D printing, Implants, Biomedical, AM methods**

## I. INTRODUCTION

The Bio printed implants or organs or small bio structures, a huge breakthrough in additive manufacturing has the potential to study and observe the motions of a body from outside the body, in three dimensions. 3Dimensional printed structure that is bio organ is likely or accurately resembling the naturally occurring system of biology performed research in two dimensions, and is highly relevant in biological means. This is widely used in the sectors of bioengineering, materials science and tissue engineering. Three dimensional bioprinting is hugely used for various sectors in medical filed that are: dental, pharmaceutical, bone replacements, organ 3d prints, and in all areas of bio related printings. This 3D printing of bio organs is the new future of mankind as it is a huge savior of human life in many ways.

## II. 3D BIOPRINTING

Bio-fabrication is defined as "the generation of biologically functional products by automation with structural organization from bioactive molecules living cells, cell aggregates such as microtissues, biomaterials, hybrid cell-material constructs through bio-assembly or bioprinting.

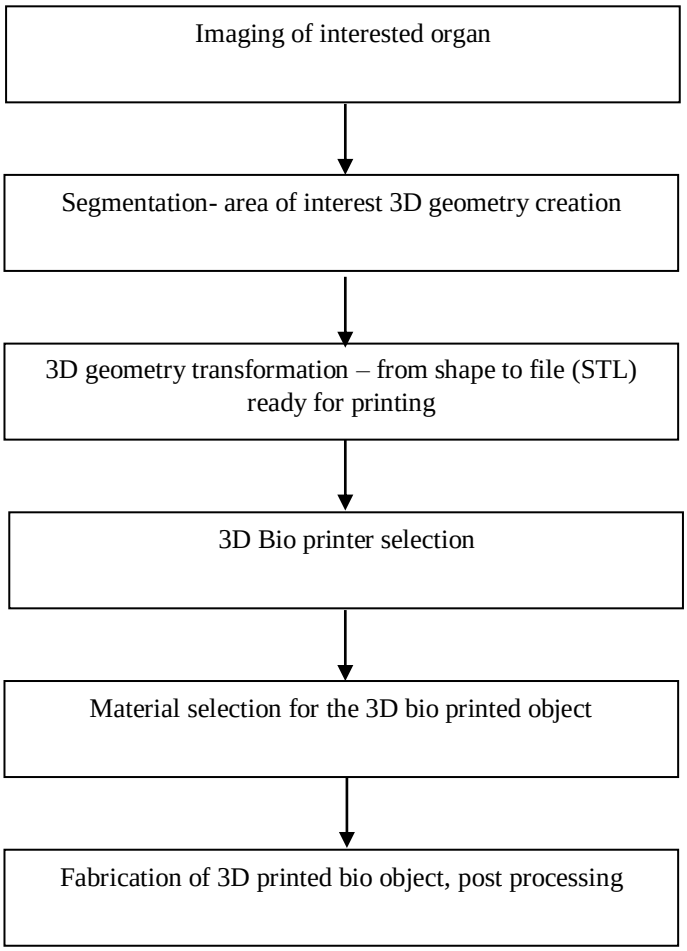


Fig. 1. Process of 3D printing of organs

Basically, three-dimensional printing of bio organs is relied on the layer-after-layer precise placing of biological matters, living cells, by placing the functional constituents. The three-dimensional bioprinting is always relied on the 3 basic things:

- biomimicry,
- self-assembly of autonomous,
- building blocks of amini-tissue.

The vital or important thing in engineering of tissue is called as the scaffold. It is a three dimensional largely porous

*International Journal of Engineering Applied Sciences and Technology, 2020*
**Vol. 5, Issue 5, ISSN No. 2455-2143, Pages 270-273**
Published Online September 2020 in IJEAST (http://www.ijeast.com)

substrate. Cells are grown in the culture-medium, which is then applied to the scaffold. Then the tissues are also grown in a growth medium and these tissues are also transferred to the proper medium using the scaffold. Biological properties of the cells are modified and controlled by scaffold composition of material as it as internal structure is changed. A diagrammatic resemblance of 3D bio printing is shown in figure below.

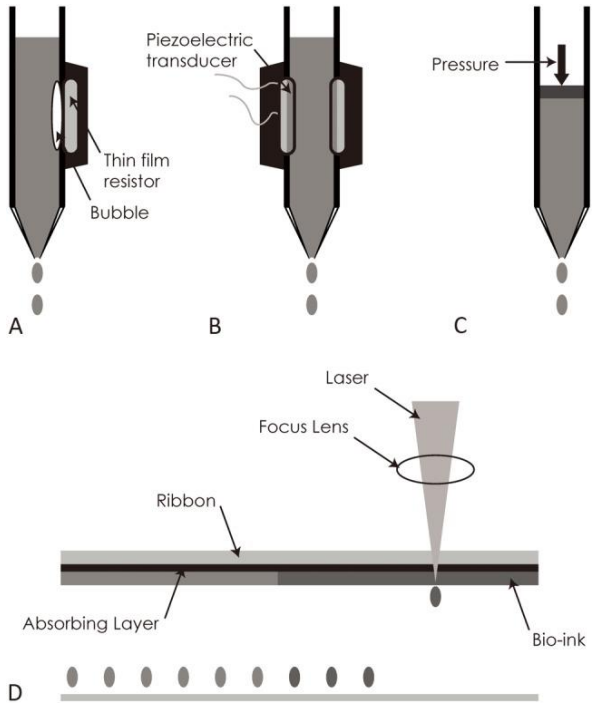


Fig. 2. Bio Printing Process

## III. Materials and Process in Biomedical AM

Famously and easily used types of 3D printing techniques used in bio field are:

- Fused deposition modelling,
- Bioprinting based on extrusion,
- Inkjet printing,
- Jet or Polyjet printing.

Biomaterials are defined as synthetic or naturally available substances which are in contact with the biological systems. These substances help in repair of damaged, replacing of cells. A three-dimensional printing bio-material should have the property of printability with good characteristics and good degradability. Other normal 3D printing materials are listed below in the Table 1.

| Material | Applications |
|---|---|
| Titanium | Bones, stent, valves made artificially |
| Ti-29Nb | Teeth, dents, implants, valves |
| P2O5 | Bones, Dental implants, orthopedic implants |
| Pd | Implants of tiny bones, knee joints |
| Cobalt | Joints of hip, knee, bones |
| Fe | Implant for spinals |
| Cp | Screw and abutment |

Table. 1. Materials used in FDM bio medical printing.

### *a) 1.1 Bio-inks for extrusion-based printing:*

Creating living tissue structures by process of forming the multi-cellular bioprinting building blocks, Cell-encapsulating hydrogels are used in 3D bioprinting. Cell encapsulation paves way for the precise spatial distribution of the cells, control over cell attachment. The bio-inks plays a vital role in 3D bioprinting as this only the available solution of extrusion-based printing. These bio-inks are made from wide variety of natural or synthetically created materials which has the property of biological as well as printability. The widely used materials for bio-inks, the popularly used materials are:

- Thickest collagen
- GelMA
- Pluronic (Pl)
- Alginate (Ag)
- PEG and
- ECM – (Decellularized extracellular matrix)

*International Journal of Engineering Applied Sciences and Technology, 2020*
**Vol. 5, Issue 5, ISSN No. 2455-2143, Pages 270-273**
Published Online September 2020 in IJEAST (http://www.ijeast.com)

Metalysis is newly developed process where metal powders are produced directly from the oxides of their metals in one step. It is done by lowering drastically of its manufacturing environmental impact-ability and other impacts. This process of innovation is cost-effective and also simple. But also, this process produces metal powders of proper uniform size so it can be used in metal 3D printing. The end product will be good enough to withstand all standards which is highly important in implants in medical sector.

| S.no | 3Dprinting method | Output remark |
|---|---|---|
| 1 | Selective laser sintering | The product finish time is less when compared to others |
| 2 | Electron beam melting | Inaccuracy is a major factor |
| 3 | Fused deposition modelling | Circular shape fabrication has less accurate shapes |
| 4 | Stereo-lithography | Over curing will cause in-accuracy in parts. |
| 5 | Inkjet printing | This method has highest build quality |
| 6 | Direct metal laser sintering | Scan speed is very good and method is fast |
| 7 | Laser metal deposition | Very good surface finish is obtained |

Table. 2. Various AM methods and their output remarks

*b) Future of 3D printing for Biomedical Applications*

The design automation, it is the thing which will be the backbone of the all the fields in world. But here in bio medical AM fields this paves way for the ease of design of very complex parts or implants. For huge scale applications within a filed of dental or clinical and future affordance is a term AM is the bridge connecting it.

Additive manufacturing has been applied in the medical field, including in complex and important surgical procedure design, surgical guide fabrication, surgical simulation, implant design and manufacturing.

The 3D printing is the future gateway for the mankind as it is the easiest and safest technology for the manufacturing of medical implants. This bioprinting is virtue that has the ability to sustain any environment. As the technology develops day-to-day it has a huge impact on humans, since humans are the one who brings new technology.

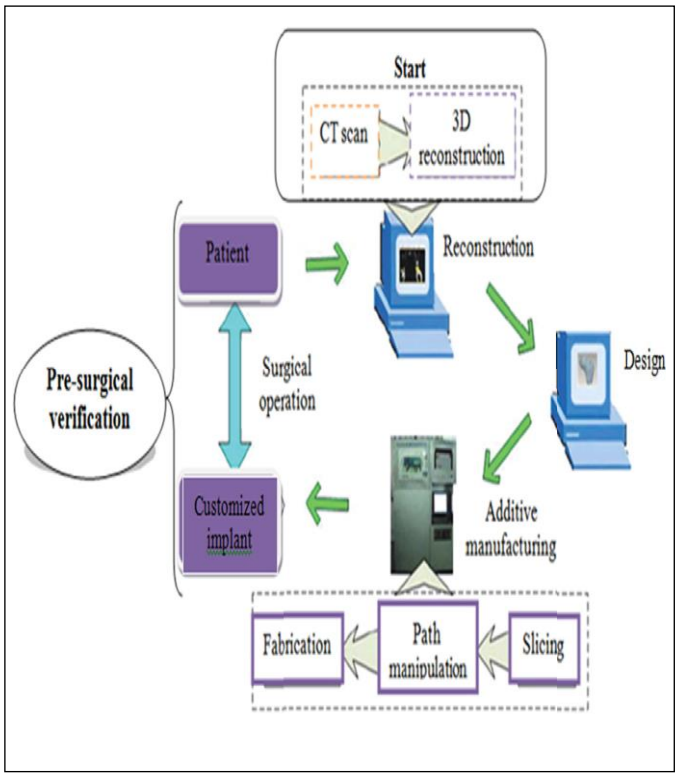


Fig. 3. Automated Biomedical AM

## IV. CONCLUSION

The bio-medical applications of additive manufacturing are huge sea, there are lots more to explore in it. As said, it's a sea, new wonders are day-by-day rising up when we are going deep down in research. Although there is not enough research done in this bio-medical field of additive manufacturing.

Biomedical additive manufactured components are required to meet the standards of international governments, as this is new era beginning and still were following old standards for the manufacturing of additive components in bio-medical field.

Thus, we can conclude by saying that additive manufacturing of biological implants is a huge benefit that mankind has got. 3D bioprinting is a sector where every field of medical is concerned and benefited.

Up to date there are still things to discover more in 3D bioprinting. This issue can be solved only when there are more reteach done in this field.

## V. REFERENCE

[1] S Bose, SF Robertson, A Bandyopadhyay (2018) Surface modification of biomaterials and biomedical devices using additive manufacturing - Acta biomaterialia

[2] J Parthasarathy, B Starly, S Raman (2011)A design for the additive manufacture of functionally graded porous structures with tailored mechanical properties for biomedical applications - Journal of Manufacturing Processes

[3] Lu B, Li D, Tian X(2015): Development trends in additive manufacturing and 3D printing. Engineering , 1(1): 085–089.

[4] LE Murr, SM Gaytan, F Medina (2010) Next-generation biomedical implants using additive manufacturing of complex, cellular and functional mesh arrays

[5] M Vaezi, S Yang (2015) Extrusion-based additive manufacturing of PEEK for biomedical applications-Virtual and Physical Prototyping.

[6] CM González-Henríquez, MA Sarabia-Vallejos (2019) Polymers for additive manufacturing and 4D-printing: Materials, methodologies, and biomedical applications-Elseviser.

[7] Strano G, Hao L, Everson RM, Evans KE(2013): Surface roughness analysis, modelling and prediction in selective laser melting. J Mater Process Technol, 213:589–597.

[8] Singh R, Singh S, Singh IP(2016): Effect of hot vapor smoothing process on surface hardness of fused deposition modeling parts. 3D Print Addit Manuf , 3(2):128 –133.

[9] Kumar P, Ahuja IS, Singh R(2016): Effect of process parameters on surface roughness of hybrid investment casting. Prog Addit Manuf , 1(1 –2):45 –53.

[10] N Sabahi, W Chen, CH Wan (2020) A review on additive manufacturing of shape-memory materials for biomedical applications – Springer.

[11] Mahamood RM, Akinlabi ET(2014): Effectof laserpoweronsurfacefinish during laser metal deposition process. In Proceedings of the world congress on engineering and computer science, vol. 2;.

[12] Su XB, Yang YQ, Peng YU, Sun JF(2012): Development of porous medical implant scaffolds via laser additive manufacturing. Trans Nonferrous Metals Soc China 22:s181–s187.

[13] Beard M, Ghita O, Evans KE(2011): Using Raman spectroscopy to monitor surface finish and roughness of components man- ufactured by selective laser sintering. J Raman Spectrosc, 42:744–748.

[14] Basalah A, Esmaeili S, Toyserkani E(2016): Mechanical properties of additive-manufactured porous titanium bio-structures with oriented macro-scale channels. Int J Adv Manuf Technol, 84(9 –12):2239 –2246.

[15] MP Chhaya, PSP Poh, ER Balmayor (2015) Additive manufacturing in biomedical sciences and the need for definitions and norms.

[16] Trelewicz JR, Halada GP, Donaldson OK, Manogharan G(2016): Microstructure and corrosion resistance of laser additively manufactured 316L stainless steel. JOM, 68:850–859.