CONTINUOUS LIQUID INTERFACE PRODUCTION (C.L.I.P)

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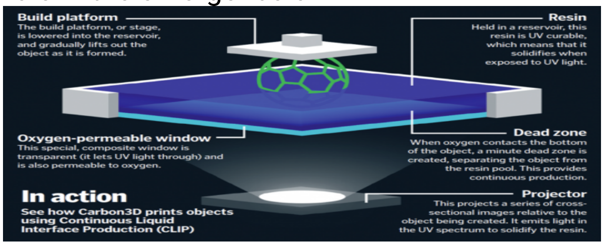
ABSTRACT :

Additive manufacturing processes such as 3D printing use time-consuming, stepwise Layer-by-layer approaches to object fabrication. We demonstrate the continuous generation Of monolithic polymeric parts up to tens of centimetres in size with feature resolution below 100 micrometres. Continuous liquid interface production is achieved with an Oxygen-permeable window below the ultraviolet image projection plane, which creates a “Dead zone” (persistent liquid interface) where photo polymerization is inhibited between the window and the polymerizing part. We delineate critical control parameters and show that complex solid parts can be drawn out of the resin at rates of hundreds of millimetres per hour. These print speeds allow parts to be produced in minutes instead of hours.

CONTENTS:

INTRODUCTION :

Rapid prototyping (RP) is a group of technologies that create three dimen sional objects additively in a layer-by-layer manner. The origin of the idea of RP can be traced back to 1890s, but RP was commercially launched only in the 1980s (Chua et al. , 2010a). The development of RP is closely tied with the development of the computer and software industry. In particular, the existence of computer-aided design (CAD) plays a critical role in the emergence of



most, if not all, of current RP systems. The primary function of RP systems is to fabricate prototypes within a short period of time (usually within hours or days) to accelerate product development. However, after three decades of development, the applications of RP extend far beyond building prototypes. In fact it has been adapted to meet the needs of a variety of industries, including design, manufacturing, automotive, aerospace, bio medical, jewelry, coin, etc. Currently, RP is rejuvenating itself in the defense and manufacturing industries, especially with the establishment of National Additive Manufacturing Innovation Institute (NAMII) in the United States (The White House, 2012) and concurrently, the Nanyang Additive Manufacturing Centre (NAMC) in Singapore. But what is important in the twenty-fi rst century is that RP, being explored to process biomaterials and biological materials, is establishing a signifi cant role in the emerging biofab rication industry to address the huge clinical demand of human tissues and organs for transplantation.

OVERVIEW OF 3D-PRINTING:

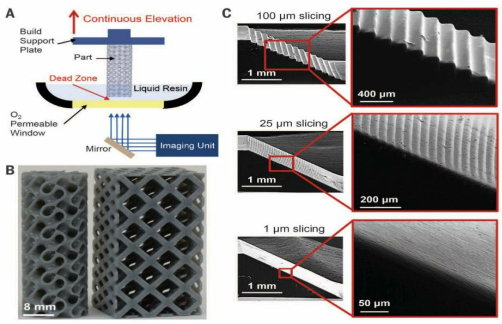
3D printing is also known as rapid manufacturing or rapid prototyping printing process, which has ability to make efficient use of raw materials and produce minimal waste while reaching satisfactory geometric accuracy [2-3]. Using this method, a design in the form of a computerized 3D solid model can be directly transformed to a finished product without the use of additional fixtures and cutting tools. These open the possibility of producing parts with complex geometry which are difficult to obtain using material removal processes. In addition, 3D printing is ability to construct complex geometries means that many previously separated parts can be consolidated into a single object.

CONTINUOUS LIQUID INTERFACE PRODUCTION:

Current additive manufacturing methods such as fused deposition modelling, selective laser sintering, and stereo lithography are inordinately slow because they rely on layer-by-layer printing processes. A macroscopic object several centimetres in height can take hours to construct. For additive manufacturing to be viable in mass production, print speeds must increase by at least an order of magnitude while maintaining excellent part accuracy. Although oxygen inhibition of free radical polymerization is a widely encountered obstacle to photo polymerizing UV-curable resins in air, we show how controlled oxygen inhibition can be used to enable simpler and faster stereo lithography.

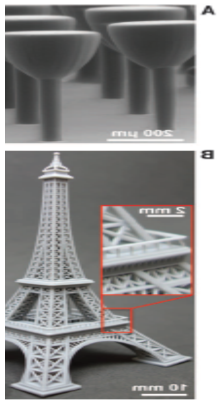
COMPONENTS USED IN C.L.I.P:

- Photo polymeric resin
- Ultra-violet light (window)
- Dead-zone
- Build platform
- Oxygen permeable resin

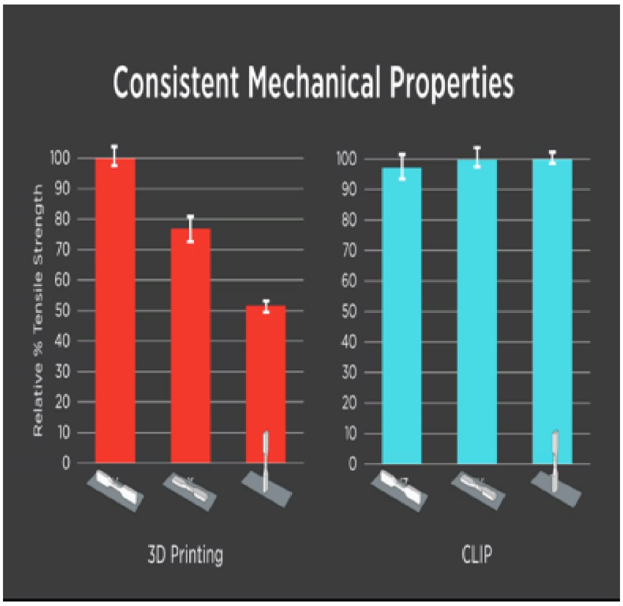


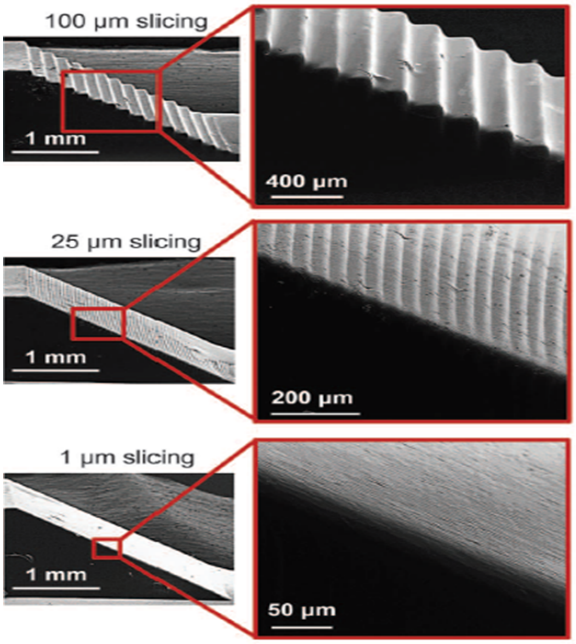
A.Schematic of CLIP printer where the part (gyroid) is produced continuously by simultaneously elevating the build support plate while changing the 2D cross-sectional UV images from the imaging unit. The oxygen-permeable window creates a dead zone (persistent liquid interface) between the elevating part and the window. (B) Resulting parts via CLIP, a gyroid (left) and an argyle (right), were elevated at print speeds of 500 mm/hour (movies S1 and S2). (C) Ramp test patterns produced at the same print speed regardless of 3D model slicing thickness (100 mm, 25 mm, and 1 mm).

C.L.I.P MODELS:



MECHANICAL PROPERTIES AND MICROSTRUCTURE:





A) Comparison of mechanical properties between 3D-printing and C.L.I.P
B) Ramp test patterns produced at the same print speed regardless of 3Dmodel slicing thickness (100 mm, 25 mm, and 1 mm).

Oracle uses Carbon's CLIP technolog 3D print thousands of end-use server brackets in days

Fluid manifold

Elastomer grommets

ADVANTAGES:

- Functions 25 to 100 times faster than the existing technologies
- Eliminating the mechanical layer-by-layer building process
- Wider choice of materials and colours through the usage of polymeric materials

DISADVANTAGES:

- Initial cost of setting up is very high.
- Since it is such an automated process, a whole assembly line of CLIP printers would only need a few technicians to monitor.

APPLICATIONS:

CONCLUSION REMARKS:

Continuous Liquid Interface Production has significant advantages over most current manufacturing methods.
These prints reduce waste, take less time, and are far cheaper than anything being used by companies today.
There is a lot of scope for the researchers in this arena to improve the build quality and to develop much more stable prototypes using versatile raw materials.

REFERENCES AND NOTES :

- Continuous liquid interface production of 3D objectsJohn R. Tumbleston,1 David Shirvanyants,1 Nikita Ermoshkin,1 Rima Janusziewicz,2Ashley R. Johnson,3 David Kelly,1 Kai Chen,1 Robert Pinschmidt,1 Jason P. Rolland,1Alexander Ermoshkin,1* Edward T. Samulski,1,2* Joseph M. DeSimone1,2,4*

- Rapid prototyping of biomaterials Principles and applications
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