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Modification in Build Plate and VAT to Improve Printing Quality of DLP 3D Printer

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Abstract: Vat polymerization process uses a vat of liquid photopolymer resin, in which the model is constructed layer by layer. An ultraviolet (UV) light is used to cure the resin where required, a build platform moves the object being made downwards after each new layer is cured. This paper shows the fabrication of DLP printer in which we use DLP projector for UV light source. And stepper motor with Arduino setup to control downward movement. This paper shows the experiments and comparison with different setups of vat and build plates to get high accuracy.
Keywords: Vat polymerization, Digital light processing (DLP), Vat, Build plate, Printing quality.

I. INTRODUCTION

Vat polymerization process can be understood by below steps.

1) The build plate is lowered from the top of the resin vat downwards by the layer thickness.
2) A UV light from DLP projector cures the resin layer by layer. The platform continues to move downwards and additional layers are built on top of the previous layers.
3) After completion, the vat is drained of resin and the object removed.

Below figure shows the printing process with vat and build plate.

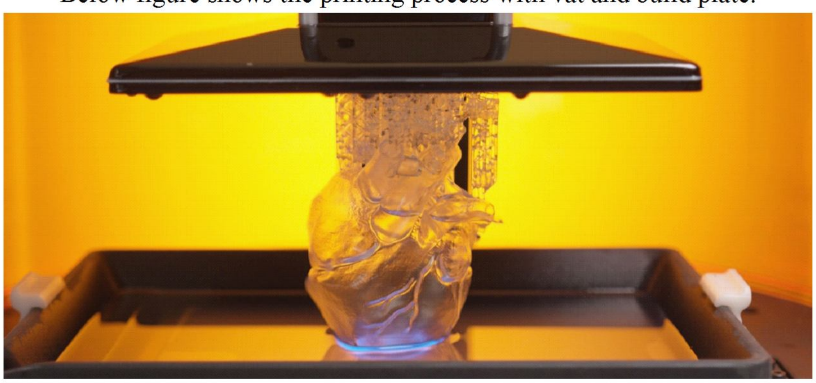

Fig1. printing process with vat and build plate [source: newpro3d.com]

A. VAT [Resin tub]

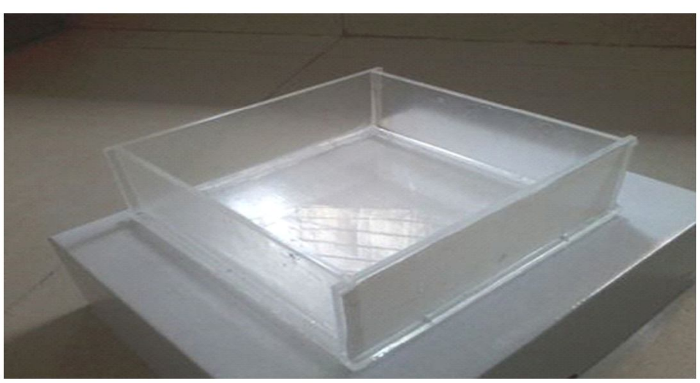

Fig2. VAT

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The DLP 3d print technology has 3 critical points in its design. The VAT is one of them. Vat Photo polymerization is another popular 3D printing process. The process is based on hardening of photopolymers on exposure to the ultraviolet radiation. The photopolymer is in the form of a liquid resin filled inside a Vat, that is why, it got the name Vat Photo polymerization. Also, we can use FPE sheet for less adhesion.

B. Build Plate

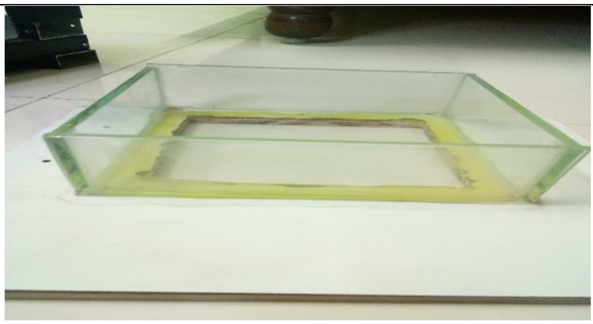
Fig3. Build plate

The z-layer build resolution is driven by the design of the build platform. The build platform is physically placed by a translation stage that consists of a carriage on a screw drive that is driven by a stepper motor in the DLP 3D Printer design. The lead screw has a pitch of 1 millimetre per revolution. The stepper motor has 200 full steps per revolution leading to a z-layer resolution of 5 micrometres per step without micro stepping the motor. Other translation stages/motor combinations can be used with the design but would require rebuilding the microcontroller code from source with the new parameters.

II. SELECTED PARTS AND SPECIFICATION

We used 3 types of vat and tested them. We used borosilicate, normal glass, plastic as our vat material. The table below shows the vat that we used and analysis of them.

Table.1 Analysis of different VAT we used.

SR.NO	VAT TYPE	IMAGE OF VAT	ANALYSIS
1	Borosilicate Glass		- Adhesion between build plate and vat. - Must use FPE sheet. - Safe and Durable at high temp. - High accuracy - More Expensive
2	Normal Glass		- Adhesion between build plate and vat. - Must use FPE sheet. - Not safe at high temperature and Brittle. - High accuracy - Expensive

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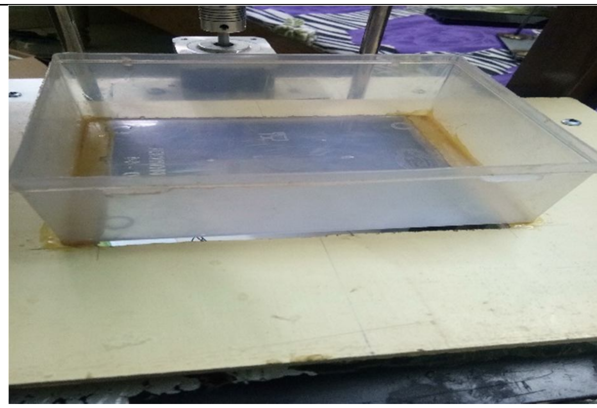
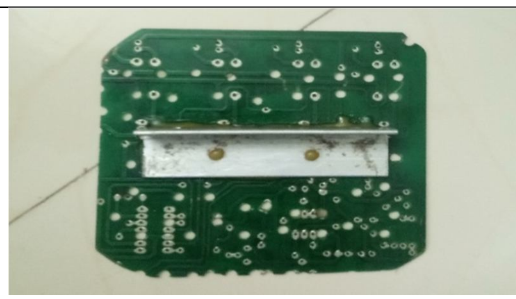
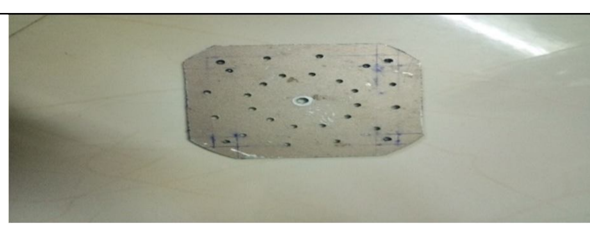
3	Plastic Vat		- No Adhesion between build plate and vat. - No use FPE sheet. - Not safe at high temperature. - Less expensive - Cheap

We used different types of build plates and tested to get better result. We used PCB plate, MS, Aluminium and SS as our build plate material. We tested these build plates and analysed the produced parts. The below table shows the various build plates with produced parts.

Table: 2 Different types of build plate we used.

SR NO.	BUILD PLATE TYPE	IMAGE OF BUILD PLATE	ANALYSIS
1	PCB plate		- Parts do not stick properly. - Consume more time. - Cheap - Light weight - Difficult attachment with machine.
2	MS plate		- Parts do not stick properly. - Consume less time. - Expensive - heavy weight - Difficult attachment with machine.
3	SS plate		- Sometime parts stick properly, but not every time. - Expensive - Medium weight - Easy to attach with machine.
4	Aluminium plate		- Parts stick properly. - Consume less time. - Cheap - Light weight - Easy to attach with machine.

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III. TESTING & ANALYSIS

We have faced this kind of problems while printing the objects:

A. Vat Problems

1) Objects were stuck with VAT.
2) Strong adhesion occurred between build plate and VAT.
3) Normal vacuum seemed between resin surface and build plate.

B. Build Plate Problems

1) Our build plate was not parallel to surface of VAT.
2) Build plate was not capable to stick the objects because of non-suitable material.
3) Build plate's surface was not good.

Table.3 Images of printed parts and problems

SR.NO	IMAGE OF PRINTED PARTS	PROBLEM	SOLUTION
1		- Adhesion occurred	- Use FEP sheet in a glass vat or use plastic vat.
2		- Uneven surface of build plate.	- Make sure your build plate is flat.
3		- We use PCB plate, which takes much time to cure layer.	- Use aluminium plate.
4		- Build plate was not parallel to the vat surface. - Build plate was not attached with machine.	- Build plate should fix properly and align with vat surface.

After we testing above combination of build plate and vat, we produced some complex parts with high accuracy.
Here are the parts that we made using our DLP 3D printer. As we can see in fig.4, we managed to produce these parts with good accuracy. As in fig.4(ii), we made a part which has 0.5mm diameter hole in the outer side.

(i) (ii)

Fig.4 Produced parts by our DLP 3D printer

In final design, we use aluminium build plate and plastic vat. We achieved very good results out of it. Here is the final setup which we used.

Fig.5 Final setup of our DLP 3D printer

IV. CONCLUSION

In the conclusion, we have concluded that when one uses the borosilicate as vat material, it is necessary to use FEP/PDMS sheet to avoid adhesion between build plate and vat. Same thing occurred in normal glass material but in vase of plastic vat no need to use FEP/PDMS sheet. Another point we conclude about build plate that your build plate should fix and fit with your machine setup properly. Also, your build plate should parallel to the surface of vat. We use aluminium as material of our build plate which brought us good accuracy in our final parts. Also, the adhesion between build plate and object is good. We also found vacuum occurred between build plate and vat which overcomed by making holes on build plate.

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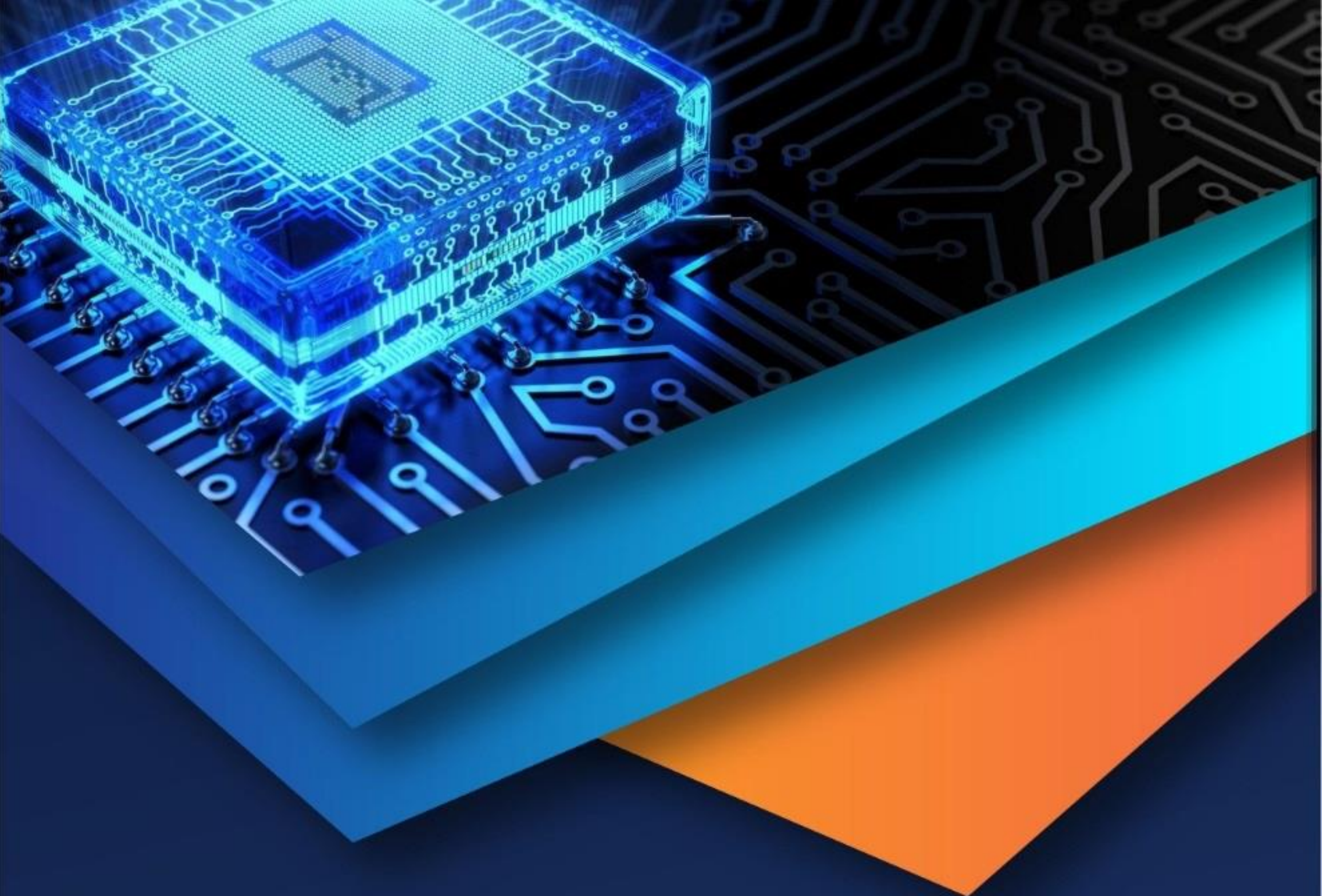

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