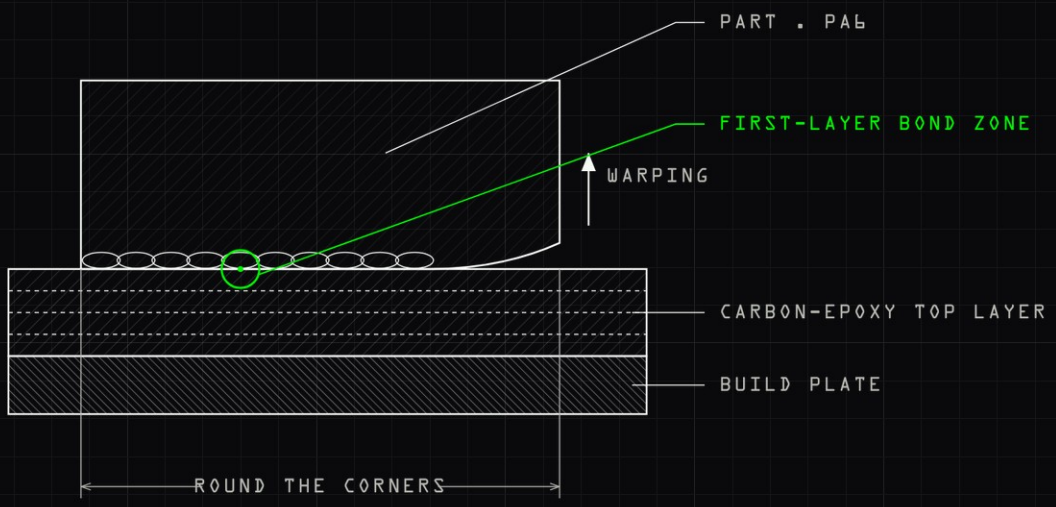
FIBERTHREE

SECTION A–A . FIRST LAYER



WHITE PAPER . WP007

PRINT BED AND ADHESION

What determines first-layer adhesion, and which surface suits which plastic?

DOCUMENT

WP007

FIBERTHREE WHITE PAPER

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00 . EXECUTIVE SUMMARY

First-layer adhesion decides whether a print succeeds. It depends mainly on the material of the build plate, on bed and nozzle temperature and on the first layer. Research at TU Darmstadt shows that, depending on the surface, the adhesion force can change by up to 60 % within 20 minutes. On resin-bonded fibre composite plates, by contrast, it remained stable.

Fiberthree build plates are available for Prusa, Raise3D and Bambu Lab. Plates for Ultimaker are no longer available.

AT A GLANCE

- **Polyamide:** print on resin-bonded fibre composite plates, such as the Fiberthree build plates. They hold reliably, need no adhesives and release parts after cooling.
- **Print bed:** set slightly above the glass transition temperature of the plastic.
- **First layer:** print slowly, slightly squished and with a little more flow.
- **PP** needs a surface of a related material; with glass fibre it becomes considerably easier.

Recommendation: Print polyamide on resin-bonded fibre composite plates, set the bed slightly above Tg and remove parts only after cooling.

up to 60 %	≈ 100 N	3
Change in adhesion force within 20 minutes, TU Darmstadt	Change in adhesion force at 40 K on the print bed	Printer families with Fiberthree build plate

01 BACKGROUND

The first layer is the foundation of every FFF part. If it does not adhere, the part detaches during printing, warps at the corners or tears off. If it adheres too strongly, it can only be removed by force afterwards, and part or build plate are damaged.

What is needed, then, is a build plate that holds firmly during printing and releases easily after cooling. This applies particularly to semi-crystalline plastics such as polyamide and PP, which shrink strongly on cooling and pull on the first layer with great force.

This paper explains what determines adhesion, compares the common surfaces and presents our Fiberthree build plates, which we offer for Prusa, Raise3D and Bambu Lab.

The chapters first cover the factors influencing adhesion, then compare the common surfaces and present the Fiberthree build plates. Settings by material family as well as defects, care and cleaning follow.

FIG. 1: SCHEMATIC
SECTION A–A . FIRST LAYER

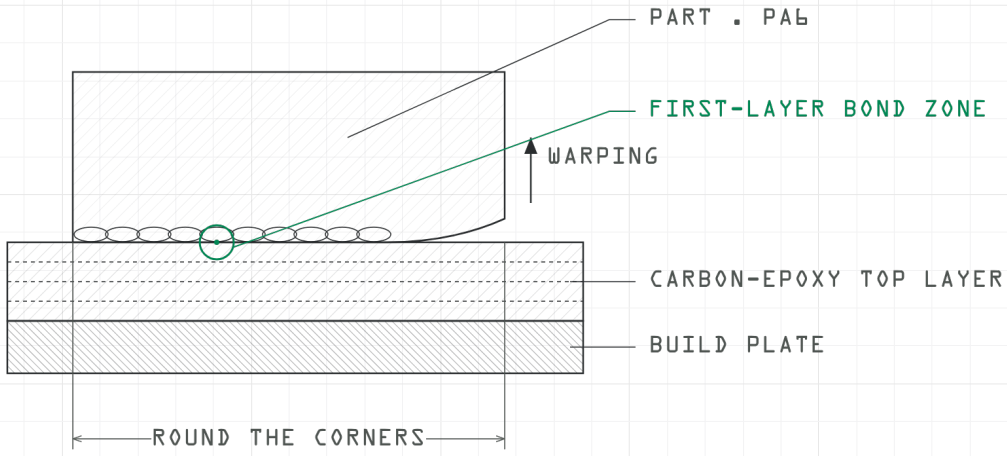


FIG. 1 First layer on the carbon-epoxy build plate, schematic, not to scale.

02 WHAT DETERMINES ADHESION

Although adhesion is so important in the FFF process, it was hardly studied scientifically for a long time. Daniel Laumann measured it systematically at TU Darmstadt with a specially developed method based on DIN EN 28510-1 [Laumann, dissertation TU Darmstadt]. He identified these influencing factors:

- the material of the build plate
- the nozzle and bed temperatures
- the print speed
- the thickness of the first layer
- the moisture content of the filament
- the contact time

BED TEMPERATURE

Adhesion rises considerably when the bed is slightly above the glass transition temperature of the plastic [Spoerk et al. 2018]. The plastic then stays soft enough at the interface to conform to the surface. Laumann measured that 40 °C more or less on the bed can change the adhesion force by about 100 N.

THE PLATE DECIDES HOW STABLE ADHESION REMAINS

Adhesion is not constant. Laumann et al. showed that the adhesion force of PLA and polyamide can change by up to 60 % within 20 minutes, depending on the plate material and temperature [Laumann et al. 2024]. On brass and borosilicate glass, adhesion was completely lost after sandblasting; on a resin-bonded fibre composite (Pertinax) it remained unchanged. The authors attribute this to hydrogen bonds between the plastic and resin-bonded or glass-like surfaces.

FIRST LAYER

For PP materials, Spoerk et al. measured higher adhesion forces with higher bed and nozzle temperatures, higher flow and a thinner first layer [Spoerk et al. 2018, Polymers]. The same applies to all plastics in principle: the first layer is slightly squished and printed with a little more material so that it fully wets the surface.

For practice this yields three adjustments in the user’s hands: the right surface, the right bed temperature and a properly set first layer. Moisture in the filament is a fourth and is ruled out by drying according to WP002.

It is important that adhesion remains stable over time. A part that adheres well in the first minutes can still detach after hours if the surface does not suit the plastic.

03 SURFACES COMPARED

There is no surface that is equally good for all plastics. For polyamide, resin-bonded fibre composite plates have proven best.

SURFACE	WELL SUITED FOR	PROBLEMATIC FOR	NOTES
Glass (borosilicate)	PLA, PETG with adhesive	PA, PP	Very flat. Adhesion is hard to maintain over time, often only with glue stick or adhesive spray
PEI, smooth or textured	PLA, PETG, ABS, ASA, PC	PA (often too weak or too strong), PP	Widely used on spring steel sheets. PETG can adhere too strongly to smooth PEI
Fibre composite, resin-bonded (carbon-epoxy, glass-epoxy, Pertinax)	PA6, PA12, fibre-reinforced polyamides, PC	PP	Very good, consistent adhesion for polyamide. Releases well after cooling. Fiberthree build plates
PP or PE plates	PP, PP composites	all others	PP adheres only to surfaces of related materials, but can weld on
Tape, adhesives	stopgap for many plastics	–	Consumables, residues on the part

TAB. 1 Print bed surfaces compared.

A special rule applies to PP: it hardly adheres to the usual surfaces and welds easily onto PP plates. Spoerk et al. found ultra-high-molecular-weight polyethylene (UHMW-PE) to be a suitable platform [Spoerk et al. 2018, Polymers]. Glass-fibre-filled PP such as F3 PP GF 25 warps considerably less and, according to its data sheet, adheres very well to the print bed.

04 FIBERTHREE BUILD PLATES

Our build plates consist of a resin-bonded carbon fibre composite. They are matched to our polyamide filaments: they are meant to hold reliably during printing and release the parts cleanly afterwards.

WHY FIBRE COMPOSITE FOR POLYAMIDE

- **Consistent adhesion:** on resin-bonded fibre composite surfaces, adhesion remains stable even over long print times. This matches the measurements by Laumann et al. on Pertinax, a related material group.
- **Release after cooling:** parts come off as soon as plate and part have cooled, usually without tools.
- **No adhesives:** polyamide adheres directly to the plate, without glue stick or spray. Our data sheets explicitly mention the excellent adhesion on epoxy-based fibre plates.
- **Robust:** the surface withstands the temperatures that polyamide and PC need on the print bed.

OUR EXPERIENCE

In our own printer fleet of more than 30 machines we print polyamides and fibre-reinforced filaments on these plates, from test specimens to small series. Our experience is very good: the first layer adheres reliably, large and flat parts warp less, and the plates last a long time.

AVAILABILITY

PRINTER	FIBERTHREE BUILD PLATE
Prusa	available
Raise3D	available
Bambu Lab	available
Ultimaker	no longer available

TAB. 2 Availability of the Fiberthree build plates.

We no longer offer plates for Ultimaker printers.

The plates are used without glue stick or spray. This saves a work step, and the underside of the parts stays free of residues. For consistent results it is enough to keep the plate clean and grease-free and to remove parts only after cooling.

Anyone running several printers also benefits from adhesion behaving the same on all plates. Print profiles can thus be transferred between machines.

05 SETTINGS BY MATERIAL FAMILY

As a starting point: bed slightly above the glass transition temperature of the plastic. The exact values are in the technical data sheet of the filament.

MATERIAL FAMILY	FIBERTHREE FILAMENTS	RECOMMENDED SURFACE	PRINT BED	NOTES
PA6	F3 PA-CF Pro, F3 PA-GF Pro, F3 PA-GF30 Pro, F3 PA Pure Pro, F3 PA ESD	Fiberthree build plate	approx. 70–90 °C	Dry filament (WP002). Data sheet specimens of F3 PA-GF30 Pro printed at 70 °C
PA12	F3 PA-CF Lite, F3 PA Pure Lite	Fiberthree build plate	approx. 60–80 °C	Excellent adhesion on epoxy-based fibre plates according to data sheet
PC	F3 PC CF 150	Fiberthree build plate or PEI	approx. 100–110 °C	Closed build chamber recommended
PP	F3 PP GF 25	according to data sheet, PP or PE plate	80 °C according to data sheet	Glass fibre considerably reduces warping
PLA	F3 PLA GF	PEI or glass	approx. 50–60 °C	uncritical
TPU	F3 TPU 80A, F3 TPU 98A	PEI or glass	approx. 40–60 °C	Often adheres very strongly, a release agent can help

TAB. 3 Print bed settings by material family.

FIRST LAYER

- Set the nozzle-to-plate distance so that the first layer is slightly squished.
- Print the first layer slowly, at about half speed.
- Increase the flow slightly for the first layer so that the surface is fully wetted.
- Part cooling fan off for the first layer, generally low for polyamide.

06 DEFECTS, CARE, CLEANING

DEFECT	CAUSE	REMEDY
Corners lift during printing	shrinkage forces greater than adhesion	warmer bed, first layer closer to the plate, round corners (WP004), choose fibre-reinforced filament
First layer does not adhere at all	gap too large, plate dirty, wrong surface	check the gap, clean the plate, choose the surface according to the table
Adhesion decreases after hours	adhesion not stable over time, build chamber cools down	fibre composite plate instead of glass, closed build chamber
Part cannot be removed	adhesion too strong, plate still warm	let the plate cool completely, release layer if needed
Tear-outs in the plate	part levered off while warm	cool first, then remove. No scraper with a sharp edge
Bubbles or rough underside	moist filament	dry the filament (WP002)

TAB. 4 First-layer defects and remedies.

CARE

- **Keep it grease-free:** fingerprints reduce adhesion. Handle the plate only at the edge.
- **Cleaning:** with isopropanol and a lint-free cloth, for heavy soiling with warm water and washing-up liquid, then dry well.
- **No adhesive residues:** remove glue stick or spray residues completely before printing polyamide.
- **Remove parts cold:** this protects plate and part.

07 CONCLUSION

The first layer decides whether a print succeeds. For polyamide, resin-bonded fibre composite plates have proven themselves: adhesion stays stable over long print times, no adhesives are needed, and the parts release after cooling. A bed slightly above the glass transition temperature, a slow, slightly squished first layer and a clean plate do the rest.

If you are unsure which surface suits a plastic, the tables in Chapters 03 and 05 give a starting point. The exact values are in the technical data sheet of the respective filament.

REFERENCES

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ABOUT FIBERTHREE

Fiberthree develops and produces technical filaments for FFF printing in Darmstadt, with polyamide at the heart of the portfolio. The ecosystem includes build plates for Prusa, Raise3D and Bambu Lab as well as the F3 Safe Light and F3 Safe Long Run dry boxes. Building on our background as an engineering office, we also offer engineering, training and contract manufacturing on more than 30 printers.

WHITE PAPER SERIES

All white papers are available at www.fiberthree.com. We update the series regularly; the latest version applies.

NO.	TOPIC	HELPS WITH
WP001	Plastics for the FFF Process: Material Overview and Process Comparison	Choosing material and process
WP002	Effect of Moisture on Polymers in the FFF Process	Drying filament and keeping it dry
WP003	Annealing and Post-Processing of FFF Parts	Annealing, conditioning, finishing
WP004	Design for Manufacturing in the FFF Process	Designing parts for FFF
WP005	Heat-Setting Threaded Inserts in FFF Parts	Detachable screw connections
WP006	Nozzle Selection for Filled Filaments	Nozzle material and diameter
WP007	**Print Bed and Adhesion (this paper)**	**First-layer adhesion**
WP008	Electrostatic Dissipative (ESD) Parts in FFF Printing	Printing and testing ESD parts
WP009	Interlayer Adhesion in the Build Direction: Nozzle Temperature, Print Speed and Hotend	Strength in the z direction

TAB. 5 Overview of the Fiberthree white papers.

FIBERTHREE

START WITH THE RIGHT MATERIAL

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QUALITY

ISO 9001

DIN EN ISO 9001:2015 .
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