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Composite Based Additive Manufacturing (CBAM) Technology – An Overview

Stronger Together

Parts Printing | Manufacturing Solutions | Personalised Service

Background

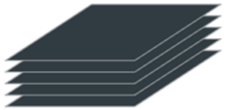
- Ricoh 3D and Impossible Objects partnership started in 2021
- Exclusive distribution of parts printed with CBAM technology to European customers
- Collaboration with Ricoh R&D team in Japan for future improvement and developments
- **Plan to have a CBAM 25 installed at Ricoh 3D in the UK in the second half of 2024**

It's fast!

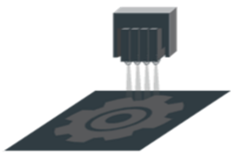
On the **CBAM-25** technology it is possible to 3D print this part **every 15 seconds…**

The process

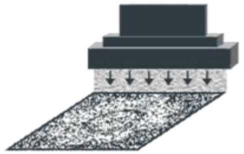
STEP 1 PRINTING PROCESS



Long-fiber sheets of carbon or fiberglass are fed into the printer.



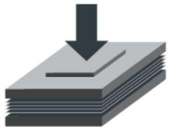
Using inkjet technology, bitmaps of CAD slices are printed onto the fiber sheets.



Polymer powder is applied to the fiber sheet, adhering to the printing fluid.

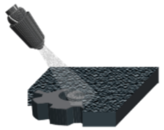
Removing excess powder leaves behind powder in the shape of the bitmap. The process repeats for all layers.

STEP 2 HEAT AND PRESS

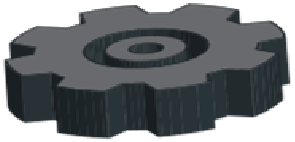


Sheets are stacked, heated to the polymer's melting point, and compressed to the designed height.

STEP 3 MATERIAL REMOVAL



Un-bonded portions of sheet fibers are removed, revealing the final part.



FINISHED PRODUCT

Material options

Fiber substrates

Non-woven composite mats typically composed of:

- Engineered fibers (12.5 to 25mm lengths)
- Random fiber orientations
- Bound together with an organic polymer binder

Examples of fiber type include:

- **Carbon fiber**
- **Fiberglass**
- Kevlar
- Thermoplastics
- Polyester

Powder matrix materials

PEEK

- High heat resistance
- Excellent chemical resistance
- Superior mechanical strength and wear resistance
- Inherent flame-retardant properties (UL94 V0 rating)

PA12

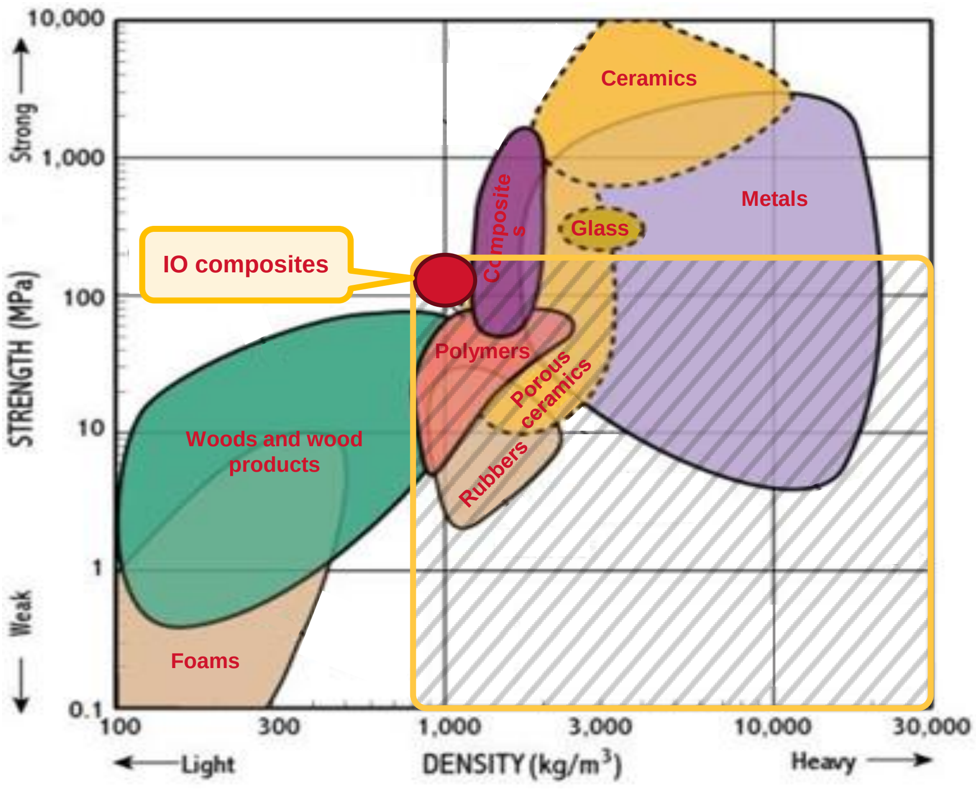
- Good abrasion resistance
- Toughness

- Other materials tested (thermosets epoxy, PA6, ULTEM, polyolefins, elastomers/TPU,…)

Key materials properties

Material Properties	TEST METHOD	CARBON FIBER NYLON 12	CARBON FIBER PEEK	FIBERGLASS NYLON 12	FIBERGLASS PEEK
Tensile Strength	ASTM D638	103 MPa *(14.9 kpsi)*	132 MPa *(19.1 kpsi)*	110 MPa *(15.9 kpsi)*	132 MPa *(19.1 kpsi)*
Tensile Modulus	ASTM D638	9.38 GPa *(1360 kpsi)*	12.74 GPa *(1848 kpsi)*	6.3 GPa *(914 kpsi)*	8.5 GPa *(1233 kpsi)*
Elongation %	ASTM D638	1.20%	1.04%	2.1%	2.5%
Ultimate Flexural Strength	ASTM D790	132 MPa *(19.1 kpsi)*	176.7 MPa *(25.6 kpsi)*	132 MPa *(19.1 kpsi)*	225 MPa *(32.6 kpsi)*
Flex Modulus	ASTM D790	9.05 GPa *(1312 kpsi)*	12.4 GPa *(1803 kpsi)*	N/A	8.5 GPa *(1233 kpsi)*
Heat Deflection Temperature (HDT)	ASTM D648 *0.455MPa / 66Pis*	167 °C *(333 °F)*	>300 °C *(>572 °F)*	N/A	N/A
Density		1.10 g/cm3 *(0.0397 lb /in3)*	1.40 g/cm3 *(0.0506 lb /in3)*	1.17 g/cm3 *(0.0422 lb /in3)*	1.25 g/cm3 *(0.0452 lb /in3)*

CBAM strength to weight close to aluminium

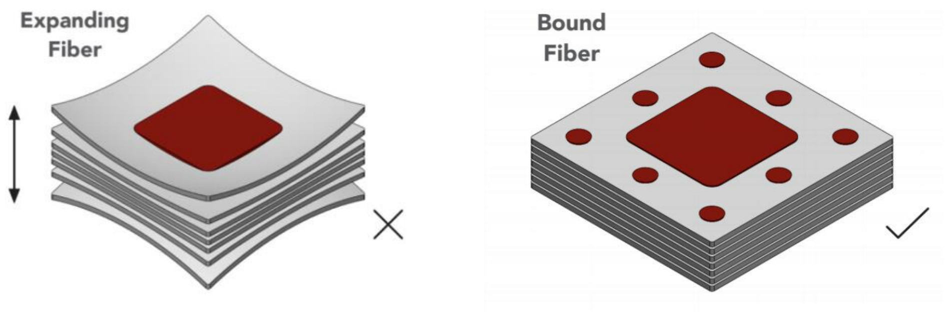


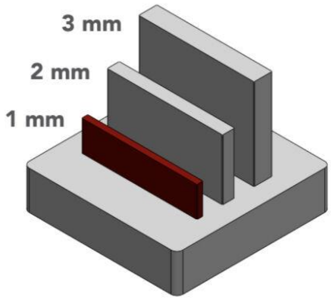
Materials in this region can be replaced by CBAM composites

About half of the weight of aluminum

Material	Density
Aluminium	2.7 g/cm3
CF-PEEK	1.4 g/cm3

Design considerations

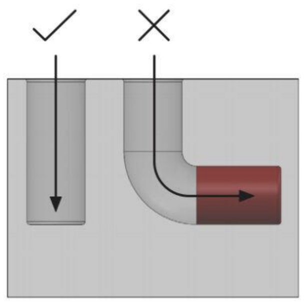


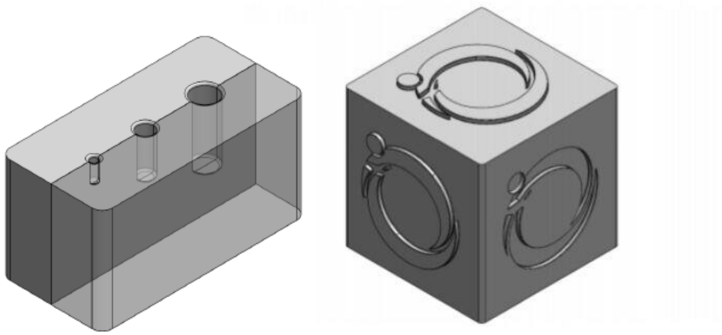


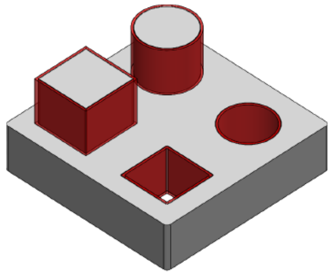
- Fibers in the unprinted area expends after compression
- The force can separate layers of the printed object
- Fibers can be bound by printing “support” features in the unprinted areas

- Walls thinner than 3 mm have a higher risk of delamination
- Thin walls require support structures to alleviate stress
- Features thinner than 2 mm risk layer separation even with support structures

Design considerations







- For excess fiber to be removed it must be visible and accessible
- Parts must have line-of-sight to every area from which fiber is to be remove

- Hole diameter must be at least 1 mm
- Embossed and engraved details possible → at least 0.5 mm wide and 1 mm tall for best results

- Standard tolerances ±0.4 mm
- Can be improved with further printing iterations
- Possibility to achieve ±0.1 mm (geometry dependent)

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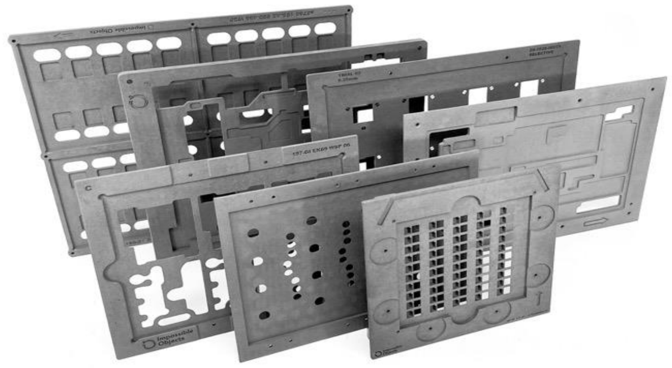
Example parts & applications

Electronic Tooling



Drones/Aerospace

General Industrial

Consumer / Sports

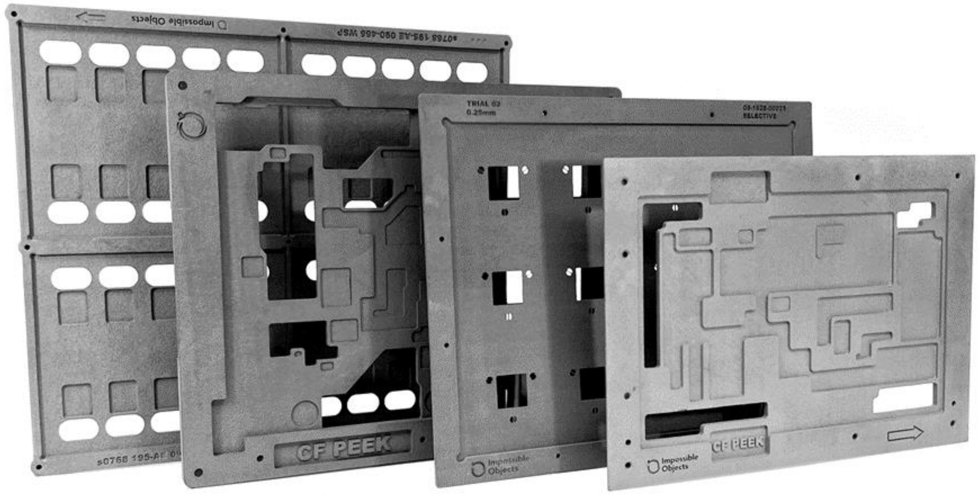
Electronic tooling

The challenge:

- Custom tooling required to manufacture all circuit boards
- Incumbent processes uses slow and costly machining of specialty composite materials or metal (aluminium, titanium)
- Leadtime up to several weeks/months

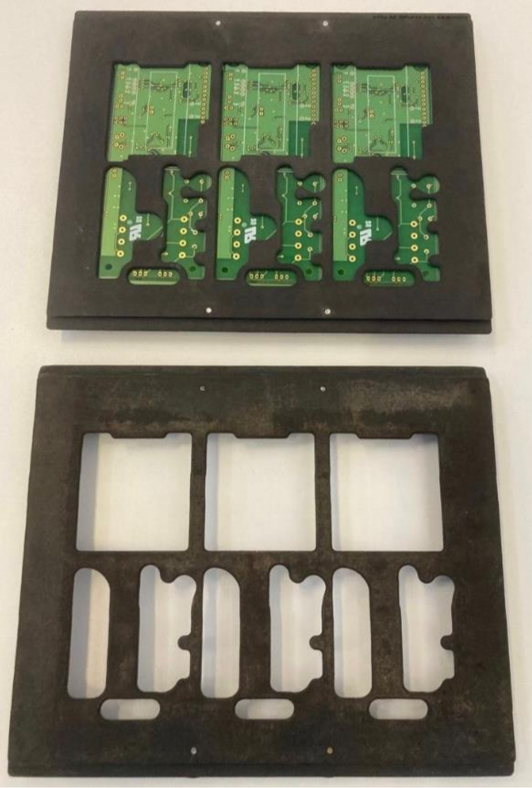
Parts produced with CBAM technology provide:

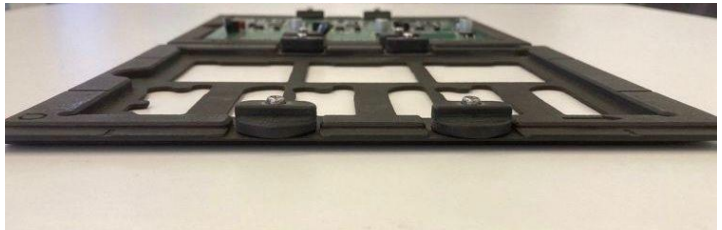
- Design flexibility (additional functionality)
- Mechanical, thermal and chemical resistance properties required by the processing conditions
- Lightweight solution (H&S, energy/maintenance cost saving)
- Leadtime reduction (50%+ reduction)
- Cost reduction (2-040% cheaper)



Tool durability

- Tool has been used for over 3000 soldering cycles
- Tool exposed to temperatures up to 265°C for short period of time (5-10 sec) and different chemicals during each cycle
- Slight discoloration but no structural changes, embrittlement or softness observed
- Initial flatness of ±1mm over 300 mm length, dimensional tolerances ±0.125 µm
- ESD material
- Flame retardant properties (UL94 V0 rating)





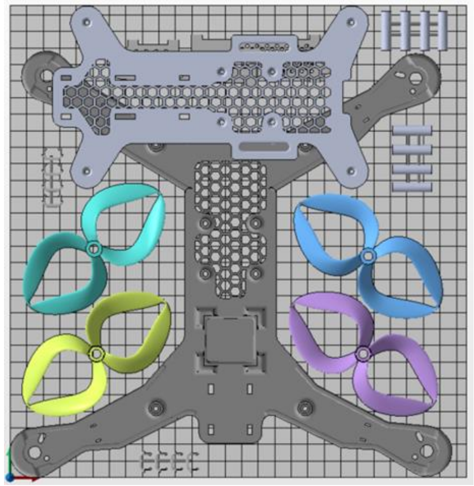
Drone manufacturing

Competitiveness

- Lighter/stronger components
- Part consolidation
- More configurable and customized
- Easier to assemble

Speed

- 1 CBAM 25 can produce 5,000 drones/month



Total number of parts: 10 parts

- **Print time:** 6 min (150 layers)
- **Heat time**: 165 minutes
- **Press time:** 2 minutes + 150 minutes cooling
- **Removal time:** 30 minutes

Summary

Designed for manufacturing

- High speed and competitive part cost
- Leveraging robust and proven 2D printing process
- High dimensional tolerances (±0.125 mm possible, limited warping)
- Load/unload while run technology for powder, inks and build blocks

High performance materials

- Long fibers enable stronger and more mechanically sound parts
- Use of high-performance polymers (PEEK) with excellent chemical and thermal resistance properties
- UL94 V0 certification

Sustainability focus

- Room temperature printing means no waste of (expensive) powders
- Possibility to recycle unfused fibers and/or work with recycled materials (powders/fibers)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CBAM 25 – Prototype machine