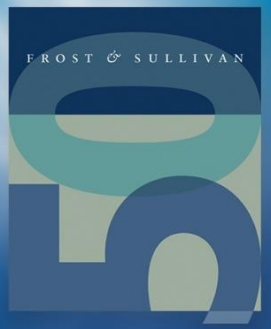
Advanced Manufacturing Alert (TechVision)

3D Printing Plastic Materials

Advancements in Plastic Materials Driving 3D Printing Industry



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Contents

Innovations in 3D Printing Plastic Materials for Fused Deposition Modeling/Fused Filament Fabrication

Polycarbonate 3D Printing Materials–Polymaker and Covestro

Tech. Profile

In the autumn of 2015 Polymaker (based in China) and Germany-based Covestro AG (formerly Bayer ScienceMaterial) launched Polymaker Polymaker PC-Plus and PC-Max, a new line of polycarbonate-based materials designed for extrusion-based fused deposition modeling (FDM)/fused filament fabrication (FFF) desktop 3D printers. Covestro has key expertise in manufacturing high-tech polymer materials.

Wide-scale Adoption

The Polymaker PC-Plus filament was slated for availability in autumn 2015; and the PC-Max version was slated for availability at the end of 2015. The materials are expected to have opportunities in FFF desktop printers over the near term.

Market Opportunity

- Manufactures of FDM/FFF desktop three-dimensional (3D) printers
- Designers, engineers, hobbyists

Competing Aspects

Extrusion-based desktop 3D printers have traditionally relied on ABS (acrylonitrile butadiene styrene) or PLA (polylactic acid) filaments that can melt at low temperature, conducive for use in mainstream printers. Polycarbonate materials, which are very durable, have required very high heat and relatively expensive industrial 3D printers.

Technology Convergence

Consumer-oriented or “prosumer” desktop FFF and SLA (stereolithography) 3D printers are finding increased opportunities in 3D printing since these much less expensive 3D printers allow getting designs to market faster.

Innovation Attributes

The polycarbonate materials have reduced printing temperatures that range from 300 to 200 degrees C to 250 to 270 degrees C, which is achievable by typical mainstream 3D printers. They also provide other benefits such as high durability, optical clarity, flame retardancy, high heat resistance (able to endure temperatures above 100 degrees C without warping), resistance to chemicals and solvents, ease of post-processing.

Market Entry Strategies

The new material has potential to compete against incumbent ABS and PLA materials, which have been widely used in fused deposition modeling. It is being exhibited at various relevant exhibitions.

Flexible Nylon Filament–Graphene 3D Lab Inc.

Tech. Profile

Graphene 3D Lab, a company that develops and manufactures proprietary composites and coatings based on graphene and other advanced materials, has added another developed filament to its product repertoire–the Scorpion Flexible Nylon 3D printing filament.

Wide-scale Adoption

The nylon filament is available for purchase in 1.75 mm and 3.00 mm diameter 400 gram spools. Such a material is anticipated to find opportunities over the next 2 to 3 years.

Market Opportunity

FDM/FFF 3D printing of furniture, containers, clothing, flexible mechanical parts.

Competing Aspects

The nylon filament is geared to provide superior resistance, very strong interlayer adhesion, enhanced bendability, compared to materials such as PLA, ABS or conventional nylon.

Technology Convergence

- Fused deposition modeling/fused filament fabrication
- Wearables (for example, clothing)

Innovation Attributes

The material's very strong resistance yields 3D printed items that can cope with repeated stress and maintain their shape. The material's superior interlayer adhesion enables 3D printing of mechanical parts with high durability. The nylon material's bendability can allow furniture and container designers to create creative shapes and prototypes.

Market Entry Strategies

The flexible nylon filament is available for purchase on Amazon, eBay, and the Graphene 3D Lab web store (Blackmagic3d.com).

High-Strength, High-Temperature Fiberglass–MarkForged Inc.

Tech. Profile

MarkForged, a company that provides desktop 3D printers that can continuously reinforce nylon parts with material such as carbon fiber or fiberglass, has launched a HSHT (high-strength, high-temperature) fiberglass material that is twice as strong as the company's standard fiberglass material. It can be used in high-heat environments such as aerospace or automotive manufacturing.

Wide-scale Adoption

100 cm^3 of the HSHT fiberglass is presently available with the Mark Two Enterprise Kit, which as an extra print bed and three sets of nozzles. The new material is expected to have key opportunities in aerospace or automotive applications that require high temperature, high-strength 3D printed materials; for example, silicone injection overmolds used to pot a Mil-Spec cable harness.

Market Opportunity

- Automotive manufacturing
- Aerospace manufacturing

Competing Aspects

While MarkForged standard fiberglass material is 40% as still as carbon fiber, the HSHT fiberglass material is up to two times stronger. The new material also provides a 30% higher heat defection point of 140 degrees C, so it can withstand environments over 105 degrees C.

Technology Convergence

- Fused deposition modeling
- 3D printing of reinforced engineering plastics
- Desktop 3D printing

Innovation Attributes

The material's high-strength, high-temperature properties will enable aerospace and automotive companies to use parts made in the MarkForged Mark Two printer for under-hood applications while still providing the benefits of same-day, desktop-created parts.

Market Entry Strategies

The new fiberglass material has been made available with MarkForged's new, faster Mark Two 3D printer.

Non-Toxic 3D Printing Filaments–Rokit and Kolon Plastics Inc.

Tech. Profile

South Korea-based Rokit, a 3D printer manufacturing company, in collaboration with Kolon Plastics Inc., developed the Skinflex and Kitchen&Deco non-toxic 3D printing materials that address and satisfy food contact requirements of the US Food Drug Administration (FDA).

Wide-scale Adoption

The new materials have potential for adoption in FDM/FFF over the relative near-term. However, ABS is a very well-established 3D printing material.

Market Opportunity

- Clothing/fashion items, shoes
- Jewelry, accessories
- Home interior items
- Baby bottles

Competing Aspects

Skinflex, a flexible, elastic 3D printing filament, is optimized for creating human wearable items (such as clothing, jewellery, and accessories), home interior items, and even soles for shoes. Using Rokit's Creator K software, the texture and surface tactility of Skinflex can be adjusted based on the user's preference. The Kitchen&Deco filament is suitable for making kitchenware, home interior items, fashion goods, and even baby bottles.

Technology Convergence

- Desktop FDM/FFF 3D printing
- Environmental health and safety
- Flexible electronics

Innovation Attributes

Polycarbonate-based thermoplastic materials used in 3D desktop printing can be toxic. Moreover, during filament extrusion and the fusion and processing of plastics, ABS releases toxic fumes (volatile organic compounds). Also, especially if extruded at temperatures higher than 200 degrees C, PLA can release VOCs. Skinflex is safe for contact with human skin. Both Kitchen&Deco filament and Skinflex do not emit carcinogens or BPA (bisphenol A).

Market Entry Strategies

A key piece of the marketing strategy for the new materials appears to be to extol the non-toxic nature of the materials and their benefits for applications that could involve contact with human skin or food

Strategic Insights

Need for Improved Properties in FDM/FFF Materials

Desired properties include:

- Strong rigorous tensile, impact, and flexural strength
- Enhanced accuracy, durability, stability
- Desirable material adhesion characteristics
- Non-fluctuating extrusion and control capability
- Improved heat resistance
- Resins with lower temperature

Opportunities for Improving Selected FDM/FFF Materials

- Opportunities to improve mechanical properties in ABS and PLA materials, resulting in stronger parts
- Develop enhanced PLA materials that feature low shrinkage, high tensile strength, high heat deflection temperature, resistance to yellowish color
- Potential for highly flexible, durable nylon
- An ideal approach would be to develop a single resin that would be suitable for use in different types of 3D printers or in various 3D printing processes

Some Emerging Materials for FDM/FFF

- Carbon fiber reinforced polymers (CFRP): Can provide enhanced mechanical strength, better stiffness, ductility, and dimensional stability
- Thermoplastic elastomers (TPEs) with improved flexibility: TPEs can address such applications as aerospace (for example, air handling ducts)
- Graphene-enhanced nylon: Could provide enhanced electrical conductivity, mechanical strength, and thermal conductivity

Challenges

- CFRP fibers can difficult to lay down; and CFRP may not have mechanical strength in the Z direction/axis
- Need for improved flexibility of TPE for FDM/FFF
- Need for demonstration of the scalability of graphene-enhanced nylon for volume commercial applications

Key Patents–Polycarbonate Material for 3D Printing

No.	Patent No.	Publication Date	Title	Assignee
1	**CN104212148**	17.12.2014	Polycarbonate composite material for 3D printing and preparation method thereof	Peach Taicang Development of New Materials Co., Ltd.
	The invention discloses an ultrahigh-viscosity polyester-polycarbonate material for 3D printing and a preparation method thereof. The ultrahigh-viscosity polyester-polycarbonate material comprises aliphatic and aromatic resins. The preparation method mainly comprises the following steps: (1) carrying out melt polycondensation to obtain low-viscosity resin; and (2) spreading low-viscosity melt resin in a special reactor and carrying out thin film melt polycondensation to obtain the target product. The preparation method of the ultrahigh-viscosity polyester material, which is provided by the invention, is simple and convenient and the ultrahigh-viscosity polyester material is suitable for being used as a 3D printing material and has important application values.			
2	**CN104558557**	29.04.2015	High-viscosity polyester-polycarbonate material for 3D printing and preparation method thereof	Institute of Chemistry, Chinese Academy of Sciences
	The invention discloses an ultrahigh-viscosity polyester-polycarbonate material for 3D printing and a preparation method thereof. The ultrahigh-viscosity polyester-polycarbonate material comprises aliphatic and aromatic resins. The preparation method mainly comprises the following steps: (1) carrying out melt polycondensation to obtain low-viscosity resin; and (2) spreading low-viscosity melt resin in a special reactor and carrying out thin film melt polycondensation to obtain the target product. The preparation method of the ultrahigh-viscosity polyester material, which is provided by the invention, is simple and convenient and the ultrahigh-viscosity polyester material is suitable for being used as a 3D printing material and has important application values. (ZH)			

Key Patents–3D Printer Filaments

No.	Patent No.	Publication Date	Title	Assignee
3	**US20160016360**	21.01.2016	**Three dimensional (3D) printer and filament material providing scanning protection for 3D printed objects**	Disney Enterprises Inc.
	A printer adapted for printing three dimensional (3D) objects that are difficult to copy by use of a 3D scanner and 3D printer. The printer includes a print head with an extrusion nozzle with a heated portion and a print bed with a surface for receiving material extruded from the extrusion nozzle. The printer includes a print material supply spool loaded with an anti-scanning filament. The print head is adapted for drawing the anti-scanning filament into the heated portion for heating prior to extrusion from the extrusion nozzle to form a 3D object. Further, the 3D object includes one or more scan protected exterior surfaces on at least one element of the 3D object. The scan protected exterior surfaces are either light absorbing surfaces or reflect light in one or more unconventional directions. The anti-scanning filament may be a plastic mixed with an anti-scanning additive such as a retroreflective material.			
4	**US20160066601**	10.03.2016	Edible 3D printer filament	Ashley G. Herr Paige Elizabeth Colen
	The present invention relates to an edible 3D printer filament that incorporates an active ingredient such as an oil extract for taste, odor or medicinal benefit, and which is capable of retaining this benefit, despite the repeated thermal extrusion involved in 3D printing. The filament is made by mixing the active ingredient extraction with polyvinylpyrrolidone (PVP), starch, and super disintegrant, and spray drying the result to a powderized form. The powderized water soluble polymer with active ingredient is mixed with excipient ingredients including a plasticizer, colored/dyed arabic gum, a gelling agent, fillers, flour, a binding or thickening agent (which also gives the benefit of being, a stabilizer), a lubricant, and a preservative, and is heated. The result is hot melt extruded into a filament with a diameter of 1.75 mm or 3 mm. When printed, the thermoplastic has good strength, stiffness, and physical properties, and can be 3D-printed in any shape.			

Industry Interactions

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