Anexo 1 Relación de patentes.

Centrándose en la tecnología de las impresoras 3D, existen diversas patentes sobre las diferentes piezas y partes de piezas que componen una impresora 3D, como por ejemplo el conjunto de cabezal de impresión [1], del cual además en la patente "Method of using print head assembly in fused deposition modeling system" [2] se describe el método de utilización del mismo.

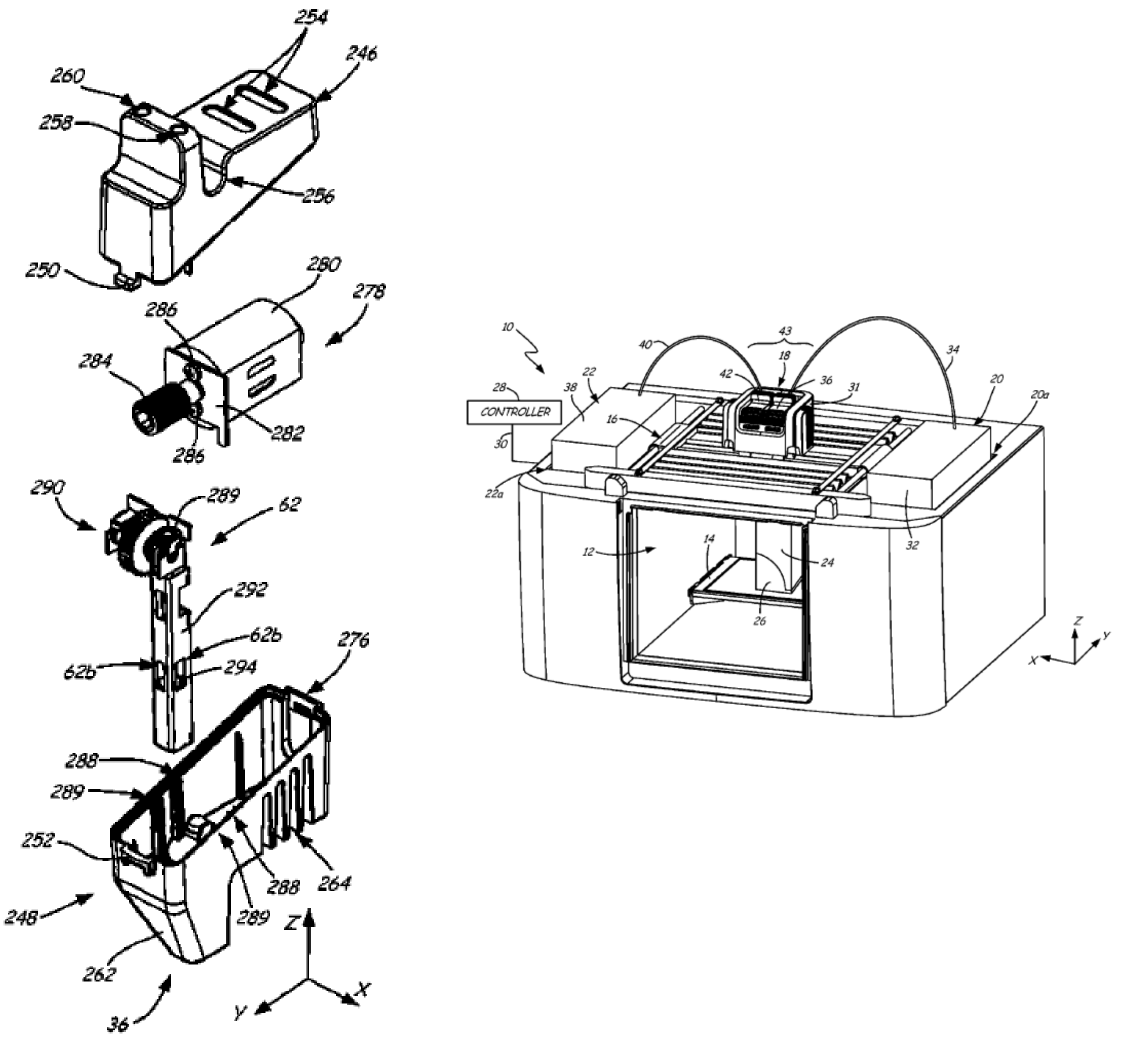

Figura 1. Conjunto de cabezal de impresión 3D.

Otras patentes se centran en la tecnología de deposición fundida en relación al procesamiento de la zona de deposición fundida durante el modelado [3] o en los métodos para la fabricación de los filamentos que se usan como materia prima en las máquinas de deposición fundida de modelado tridimensional [4], controlando el diámetro y la desviación estándar del filamento para satisfacer los distintos requisitos de tolerancia, resultando un filamento destinado a la elaboración de modelos de alta calidad.

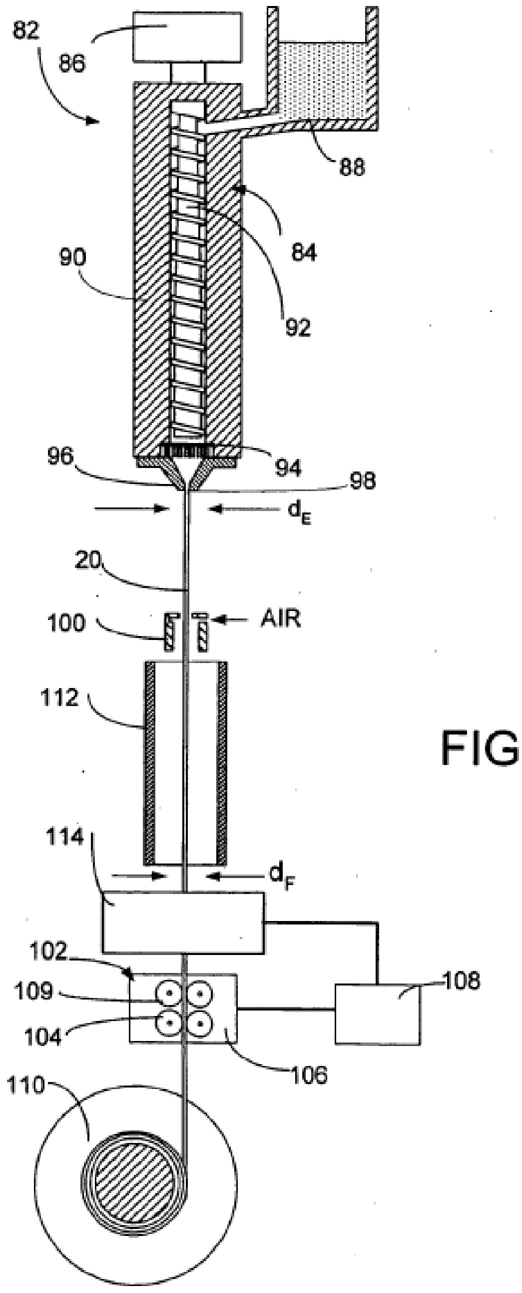

FIG.9

Figura 2. Equipo y método para la fabricación de filamentos para la elaboración de modelos de alta calidad en máquinas de deposición fundida.

Los soportes y los apoyos durante la impresión de objetos tridimensionales, que tienen partes que sobresalen suspendidas libremente en el espacio, sin ningún material del objeto en contacto, es otro tema sobre el que versan diferentes patentes [5,6], debido a la importancia que presentan estos elementos sin los cuales determinados objetos no podrían ser impresos.

El objetivo primordial es que estos elementos de apoyo o soportes sean, una vez impresa la pieza en 3D, fácilmente desmontables, extraíbles, rompibles o solubles en algún líquido. En este sentido el inventor D. J. Tafoya [7] propone procedimientos en general para la creación de piezas de prototipado rápido, y más particularmente, presenta un contenedor diseñado para la eliminación del material de soporte temporal que se utiliza generalmente en la producción de piezas de prototipado rápido.

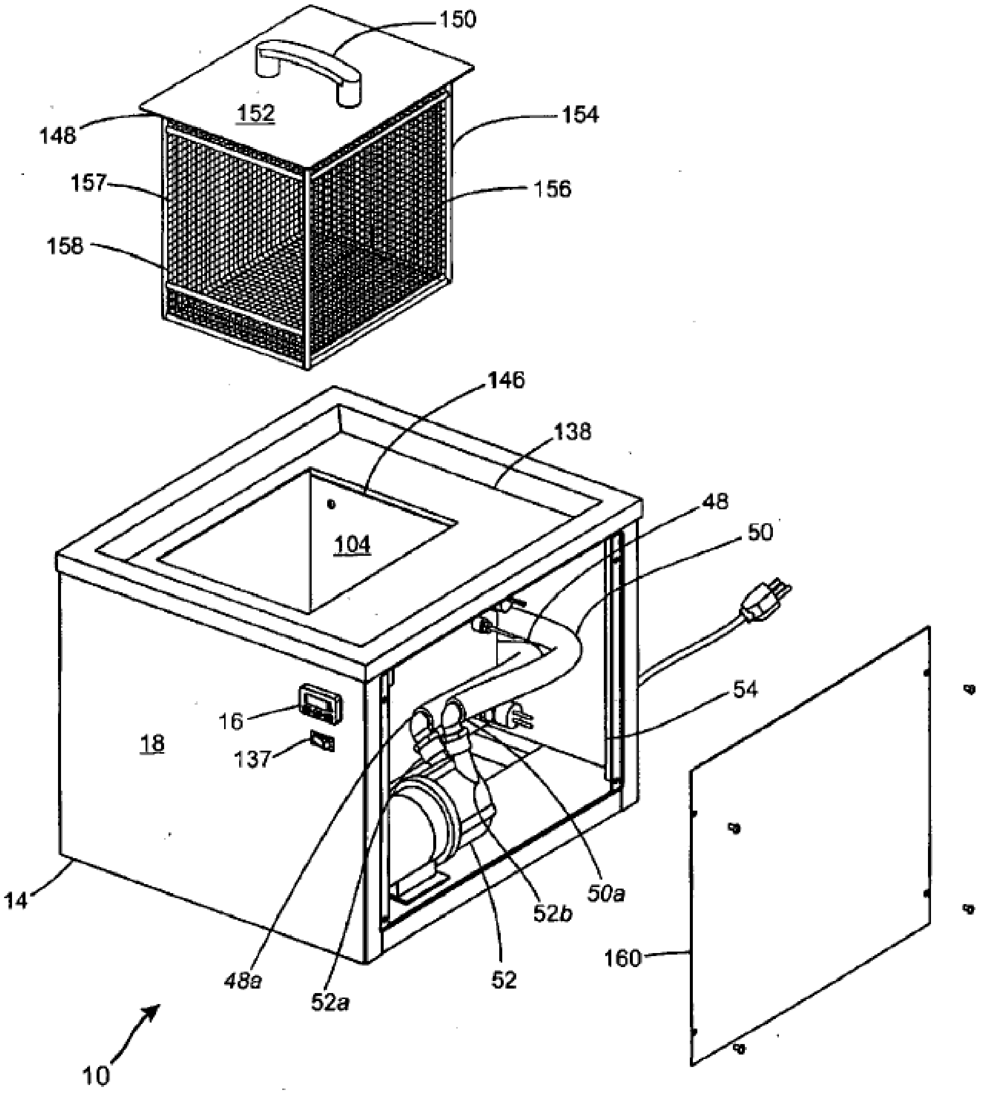

Figura 3. Contenedor para la eliminación del material de los soportes temporales.

En cuanto a los materiales utilizados como materia prima para la impresión de piezas en 3D, existen diferentes patentes principalmente entorno al ácido poliláctico (PLA) y al acrilonitrilo butadiene estireno (ABS), siendo estos como ya se comentó anteriormente los termoplásticos más utilizados en la tecnología FDM.

Estas patentes relatan métodos para optimizar las propiedades finales de las piezas elaboradas con estos termoplásticos ya que los mejoran o dan soluciones a determinados problemas durante la impresión, como por ejemplo el ablandamiento prematuro de los filamentos de PLA en la fabricación de artículos tridimensionales, siendo que se propone un nuevo PLA poli-cristalino que se puede utilizar en la fabricación de artículos tridimensionales sin que se produzcan los problemas asociados con el ablandamiento prematuro, tales como mala calidad de las piezas impresas o los atascos en la impresora [8].

De la mano de tratar de optimizar las propiedades finales de las piezas elaboradas se propone una invención que da a conocer un material de ácido poliláctico nano-endurecido de prototipado rápido. El material de ácido poliláctico nano-endurecido es una mezcla que incluye microesferas de ácido poliláctico y de poliacrilato. Sobre la base de mantener el excelente rendimiento del ácido poliláctico, el nuevo material de ácido poliláctico nano-endurecido presenta un mejor rendimiento mecánico, particularmente en fuerza de choque y tenacidad [9].

Continuando con el PLA, otras patentes proponen diferentes métodos de procesamiento del ácido poliláctico modificados para mejorar la dureza, la resistencia al impacto y la temperatura de distorsión por calor del mismo, confiriendo a este material mayores perspectivas de aplicación en impresiones 3D [10] o dan a conocer métodos de preparación de un compound de ácido poliláctico para la impresión 3D (tridimensional), en el que el PLA se endurece y modifica por la adición de un material nano-inorgánico, de forma que mediante un método simple se mejora la tenacidad de las piezas fabricadas en 3D y se supera la capacidad de procesamiento, facilitando la producción industrial [11].

En otra invención también se propone un método de preparación modificado para el acrilonitrilo butadiene estireno (ABS) para su utilización en las impresoras 3D, que proporciona las ventajas de que el nuevo ABS modificado exhibe un rendimiento mecánico excelente y una buena resistencia a la flexión [12].

Otros termoplásticos también han sido investigados para la elaboración de piezas 3D, dando a conocer una técnica de modelado en el que un modelo tridimensional y su estructura de apoyo son construidos por modelado por deposición fundida, usando para ello un blend termoplástico formado por polifenilsulfona (PPSF) y policarbonato (PC). La mezcla PPSF/PC presenta una buena resistencia química, estabilidad térmica y resiste la acumulación en la boquilla de un aparato de modelado tridimensional. La eliminación de la estructura de soporte del modelo, una vez completado, se facilita operando en el material mientras está caliente [13].

Por ultimo cabe citar la utilización de silicona para formar compuestos con diferentes termoplásticos, siendo que estos compounds con silicona presentan una buena estabilidad térmica y resisten la acumulación en la boquilla de un cabezal de extrusión o la cabeza de chorro de un aparato de modelado tridimensional. En los soportes o apoyos, la silicona contenida en el termoplástico actúa como un agente de liberación para facilitar la retirada de la estructura de soporte del modelo después de su terminación [14].

Las aplicaciones posibles de la tecnología 3D son infinitas y algunas de ellas ya están siendo objeto de patentes, como por ejemplo una invención que se refiere a la creación de prototipos de objetos moldeados por inyección y más particularmente a métodos para la fabricación de herramientas de moldeo rápido para su uso en los procesos de creación de prototipos de moldeo por inyección de plástico [15].

Los artículos de vestir se están convirtiendo en un objetivo claro de aplicación de la tecnología de impresión 3D. En el siguiente apartado se desarrollará este tema con más amplitud, pero las investigaciones en torno a este tema ya están empezando a dar su fruto en forma de patentes, como por ejemplo la invención que se refiere en general a métodos y aparatos para la fabricación de artículos. Más en particular, los aspectos de esta invención se refieren a métodos de fabricación de moldes y componentes del molde formados utilizando la tecnología de prototipado rápido, los moldes que se utilizan para la fabricación de artículos, incluyendo artículos portátiles como el calzado, incluidas las suelas, medias-suelas, partes superiores, tacones, correas de reloj, joyería, equipamiento deportivo, como espinilleras, palos de hockey, protectores de pecho, máscaras, equipos de golf y similares [16].

Y también el sector médico es otro de los campos emergentes en aplicaciones de la tecnología de impresión 3D. Este tema también será desarrollado con más amplitud en el siguiente apartado, pero cabe citar algunas patentes, como por ejemplo una invención que proporciona un método para la fabricación de un andamio biomimético por modelado por deposición fundida [17], otra que se centra en la utilización de técnicas de modelado por deposición fundida y la impresión tridimensional para crear una cáscara empleada para la fabricación de una pieza de restauración dental [18], otra que trata de como formar la materia prima en forma de filamentos o alambres que serán usados en una máquina de deposición fundida de modelado, con el fin de construir materiales de restauración dental, utilizando software de diseño asistido por ordenador [19] y por ultimo otra que versa sobre el prototipado rápido de las carcasas de transductores de ultrasonidos mediante impresión 3D [20].

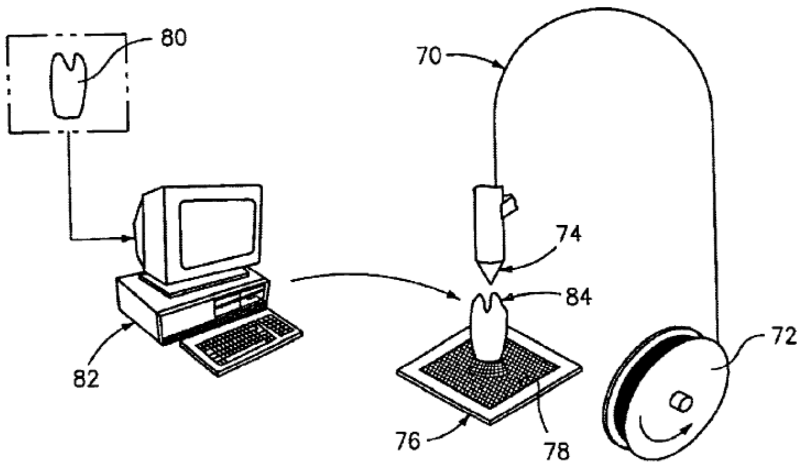

Figura 4. Construcción de materiales de restauración dental, por deposición fundida, utilizando software de diseño asistido por ordenador.

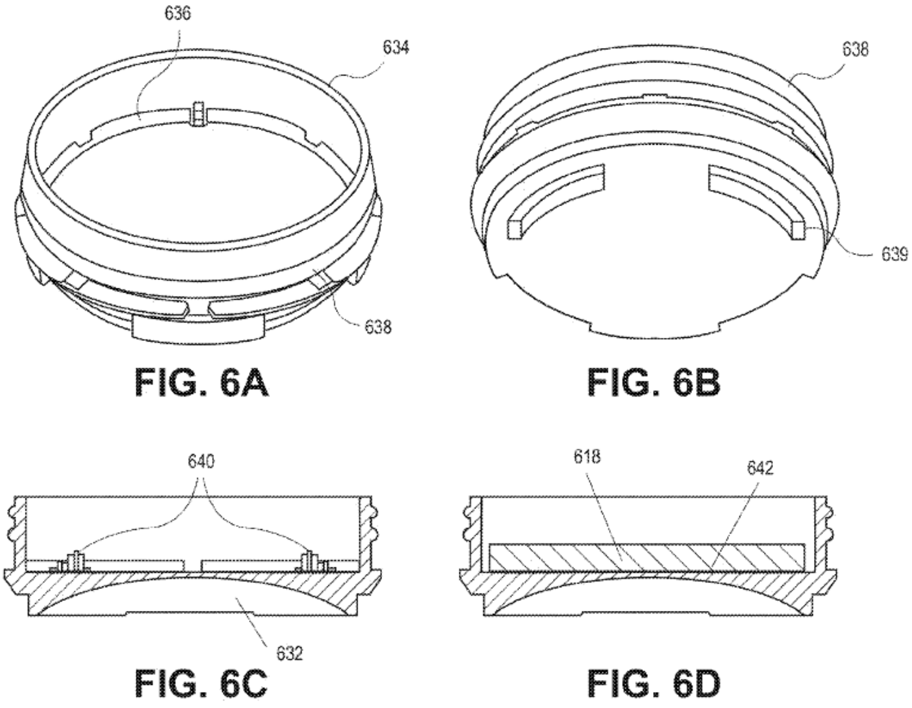

Figura 5. Carcasas de transductores de ultrasonidos mediante prototipado rápido.

REFERENCIAS.

1. Swanson, W.J., Batchelder, J.S. and Johnson, K.C., "**Print head assembly for use in fused deposition modeling system**"; Google Patents, 2013.

Resumen

A print head assembly that includes a print head carriage and multiple, replaceable print heads that are configured to be removably retained in receptacles of the print head carriage.

2. Swanson, W.J., Batchelder, J.S. and Johnson, K.C., "**Method of using print head assembly in fused deposition modeling system**"; Google Patents, 2012.

Resumen

A method of using a print head assembly that includes a print head carriage and multiple, replaceable print heads that are configured to be removably retained in receptacles of the print head carriage.

3. Zhang, H. and Wang, G., "**Method for manufacturing metal parts and molds and micro-roller used therefor**"; Google Patents, 2013.

Resumen

A method for manufacturing parts and molds by: 1) slicing a three-dimensional CAD model of a part or mold; 2) planning a modeling path according to slicing data of the three-dimensional CAD model, whereby generating numerical control codes for modeling processing; and 3) performing fused deposition modeling of powders or wire material of metal, intermetallic compounds, ceramic and composite functional gradient materials by layer using a welding gun on a substrate layer via a numerical control gas shielded welding beam or laser beam according to a track specified by the numerical control code for each layer. A micro-roller or a micro-extrusion unit is installed at a contact area between melted and softened areas. The micro-roller or the micro-extrusion unit synchronously moves along with fused deposition area, which results in compressing and processing of the fused deposition area during the fused deposition modeling.

4. Comb, J., Priedeman, W., Leavitt, P., Skubic, R. and Batchelder, J., "**High-precision modeling filament**"; Google Patents, 2005.

Resumen

Disclosed is a modeling filament for use as feedstock in a fused deposition modeling liquifier, and a method for manufacturing the filament. The diameter and standard deviation of the filament are controlled to meet various tolerance requirements of jam resistance, slip resistance, model strength, liquifier overflow prevention and hysteresis-free transient response. Standard deviation of the filament diameter is matched to a filament target diameter. The resulting filament is used to form high-quality models.

5. Leyden, R., Thayer, J., Bedal, B., Almquist, T., Hull, C., Earl, J., Kerekes, T., Smalley, D., Merot, C. and Fedchenko, R., "**Selective deposition modeling method and apparatus for forming three-dimensional objects and supports**"; Google Patents, 2004.

Resumen

A variety of support structures and build styles for use in Rapid Prototyping and Manufacturing systems are described wherein particular emphasis is given to Thermal Stereolithography, Fused Deposition Modeling, and Selective Deposition Modeling systems, and wherein a 3D modeling system is presented which uses multijet dispensing and a single material for both object and support formation.

6. Crump, S.S., Comb, J.W., Priedeman, W.R. and Zinniel, R.L., "**Process of support removal for fused deposition modeling**"; Google Patents, 1996.

Resumen

Processes and apparatus are disclosed for producing three-dimensional objects having overhanging portions freely suspended in space without any material of the object in direct, supporting engagement therewith in the final geometry of the object. A support structure is formed by depositing material which will be under the ultimately suspended portions of the object to be formed, during a process in which material is built up in layers to form the object as well as the underlying support structure. A readily removable support structure is formed along an interface with the underside of the suspended portion of the object structure. A weak, removable or breakable joint is formed along that interface by the use of an interface material which forms a weak or dissolvable bond with the material of the object. The release material may be deposited as a separation layer, or as a thin coating.

7. Tafoya, D.J., "**Removing Soluble Support Material From Rapid Prototype Part**"; Google Patents, 2009.

Resumen

A container has been devised for use with a rapid prototype part making machine, specifically of the type having Fused Deposition Modeling (FDM) capabilities. The container includes a liner that has an exterior surface and that is expandable to define a mouth portion and a volume for receiving, via the mouth portion, a rapid prototype part having soluble support material deposited on the rapid prototype part. An inlet port is formed on the exterior surface and is in fluid communication with the volume. An outlet port is formed on the exterior surface and is in fluid communication with the volume. A sealing arrangement is configured and arranged to selectively substantially prevent egress of an aqueous cleaning solution from the mouth portion of the liner. The inlet port is configured to introduce the aqueous cleaning solution into the volume to remove the soluble support material from the rapid prototype part.

8. Luo, X. and PEI, Z., "**Highly crystalline poly (lactic acid) filaments for material-extrusion based additive manufacturing**"; Google Patents, 2015.

Resumen

This invention involves a new and better solution to the problems associated with the premature softening of PLA filaments in the additive manufacturing of three dimensional articles. It is based upon the finding that poly(lactic acid) filaments with high crystallinity offer much better resistance to heat-induced softening. The crystalline poly(lactic acid) filament of this invention can accordingly be used in the additive manufacturing of three dimensional articles without encountering the problems associated with premature softening, such as poor quality and printer jamming. The crystalline poly(lactic acid) filaments of this invention can also be used in additive manufacturing of three dimensional articles without compromising the quality of the ultimate product, reducing printing speed, increasing cost, or leading to increased printer complexity. This invention more specifically discloses a filament for use in three-dimensional printing which is comprised of crystalized poly(lactic acid), wherein said filament has a diameter which is within the range of 1.65 mm to 1.85 mm.

9. 罗小帆, 罗., "**Nano-toughened polylactic acid material for rapid prototyping and preparation method thereof**"; Google Patents, 2013.

Resumen

The invention discloses a nano-toughened polylactic acid material for rapid prototyping. The nano-toughened polylactic acid material is a mixture including polylactic acid and polyacrylate microspheres. The invention further provides a preparation method of the nano-toughened polylactic acid material. The preparation method comprises the following steps of: (1) preparing the polyacrylate microspheres; (2) carrying out dry mixing and drying on the polylactic acid and the polyacrylate microspheres to form a blend material; or, mixing the polylactic acid and the polyacrylate microspheres by using a solvent method for precipitation, and carrying out drying to form the blend material; (3) carrying out melt blending on the blend material by using a twin-screw extrusion method and carrying out granulation; and (4) after drying the manufactured particles, processing the particles into monofilaments through a single-screw extruder. On the basis of maintaining the excellent performance of the polylactic acid, the nano-toughened polylactic acid material is improved in mechanical performance, particularly in shock strength and toughness. Compared with the traditional polylactic acid modification method, the preparation method disclosed by the invention is easier for production and industrialization and has no change or fewer changes to the appearance and transparency of the traditional polylactic acid, and the nano-toughened polylactic acid material is easier to color.

10. 陈庆, 李., 曾军堂, "**3D printing modified polylactic acid material and preparation method thereof**"; Google Patents, 2013.

Resumen

A 3D printing modified polylactic acid material comprises, by weight, 70-85 parts of polylactic acid, 1-5 parts of chain extenders, 1-5 parts of cross-linking agents, 0.5-1 part of nucleating agents, 5-10 parts of polymers with low molecular weights, 5-10 parts of flexibilizers, 1-5 parts of fortifiers and 0.3-0.8 part of antioxidants. According to the 3D printing modified polylactic acid material, a low-temperature smashing hybrid reaction technology is utilized, modified processing is carried out on polylactic acid, toughness, impact strength and the heat distortion temperature for the polylactic acid are improved to a large extent, and the polylactic acid can have wider application prospects in 3D printing materials.

11. 陈庆, 李., "**Preparation method of polylactic acid material for 3D (three-dimensional) printing**"; Google Patents, 2014.

Resumen

The invention discloses a preparation method of a polylactic acid material for 3D (three-dimensional) printing. The polylactic acid material is toughened and modified by an inorganic nano material. The method comprises the steps as follows: firstly, surface organic modification is performed on a coupling agent for a nano inorganic toughening agent with an ultrasonic treatment technology, then the modified nano inorganic toughening agent, polylactic acid, a plasticizer and a dispersing agent are ground, dispersed and mixed, and finally, the toughened and modified polylactic acid material applicable to a 3D printing technology is prepared through an extruding granulation and drawing technology. According to the method, defects that existing polylactic acid materials for the 3D printing are poor in toughness and processability are overcome, and the method is simple to operate and capable of facilitating industrial production.

12. Gu, J., Huang, X. and Zhao, H., "**Preparing modified acrylonitrile butadiene styrene (ABS) material for 3D printers, involves providing butadiene, styrene, acrylonitrile and plasticizer, granulating to form ABS particles and extruding with polysulfone particles**"; Changzhou Hanbang Eng Plastics Co Ltd.

Resumen

NOVELTY - Preparation of modified acrylonitrile butadiene styrene (ABS) material involves: (1) providing butadiene, styrene, acrylonitrile, UV absorber, plasticizer, polymerization inhibitor, impact modifier, carbon fiber reinforcing material, organosiloxane and polysulfone materials to prepare polybutadiene rubber; (2) configuration of the polybutadiene rubber to achieve phase transition; (3) a multistage phase transformation and devolatilization; (4) granulating the material to obtain ABS particles; and (5) extruding and granulating the ABS particles with polysulfone particles. USE - The method is useful for preparing ABS material, which is useful for 3D printers. ADVANTAGE - The modified ABS material exhibits excellent mechanical performance and bending strength. DETAILED DESCRIPTION - Preparation of modified acrylonitrile butadiene styrene (ABS) material involves: (1) providing 5-30 %mass butadiene, 40-0 %mass styrene, 15-35 %mass acrylonitrile, 5-15 %mass UV absorber, 8-26 %mass plasticizer, 1-15 %mass polymerization inhibitor, 2-18 %mass impact modifier, 5-35 %mass carbon fiber reinforcing material, 4-15 %mass organosiloxane and polysulfone materials to prepare polybutadiene rubber; (2) configuration of the polybutadiene rubber dissolved in styrene and acrylonitrile monomers to achieve phase transition; (3) a multistage phase transformation, and when the conversion rate reaches more than 70%, carrying out devolatilization process; (4) granulating the material to obtain small particle size ABS particles; and (5) extruding and granulating the ABS particles with small particle size polysulfone particles to obtain the target product.

13. Hopkins, P., "**Material and method for three-dimensional modeling**"; Google Patents, 2004.

Resumen

Disclosed is a modeling technique wherein a three-dimensional model and its support structure are built by fused deposition modeling, using a thermoplastic blended material containing a polyphenylsulfone (PPSF) polymer and a polycarbonate (PC) polymer to form the model. The PPSF/PC blend exhibits good chemical resistance, thermal stability, and resists build-up in the nozzle of a three-dimensional modeling apparatus. Removal of the support structure from a completed model is facilitated by operating on the material while it is hot.

14. Priedeman, W., "**Material and method for three-dimensional modeling**"; Google Patents, 2008.

Resumen

A three-dimensional model and its support structure are built by fused deposition modeling techniques, wherein a thermoplastic material containing silicone is used to form the support structure and/or the model. The thermoplastic material containing silicone exhibits good thermal stability, and resists build-up in the nozzle of an extrusion head or jetting head of a three-dimensional modeling apparatus. The silicone contained in a support material acts as a release agent to facilitate removal of the support structure from the model after its completion.

15. Priedeman, W. and Scott, S., "**Layered deposition bridge tooling**"; Google Patents, 2006.

Resumen

Disclosed is a method for making a prototype plastic injection molded part from a mold tool (10) built by fused deposition modeling. The mold too (10)l is built by depositing roads of a molten thermoplastic resin in layers in a predetermined pattern defined by computer file data representing the inverse of the desired prototype molded part, and is used in an injection molding machine without the addition of any reinforcement fill material or layers to create the prototype part. The disclosed method provides prototype plastic injection molded parts within a twenty-four hour time period.

16. Dean, A.C., "**Method and Apparatus for Manufacturing Components Used for the Manufacture of Articles**"; Google Patents, 2012.

Resumen

Methods of manufacturing wearable articles include: (a) performing a scan of a body part of a user on which the wearable article will be worn; (b) creating a virtual design of a mold insert configured to mold the wearable article, based on the scan; (c) saving the virtual design in a data file; (d) fabricating the mold insert using a laser sintering, fused deposition modeling, and stereolithography technique; (e) inserting the mold insert into a mold; (f) inserting moldable material into a cavity created at least in part by the mold insert; (g) molding the moldable material to produce the wearable article; and (h) removing the wearable article from the mold. The wearable article may include a portion of an article of footwear, such as a portion of a shoe sole.

17. Jabbari, E., "**Fabrication of Biomimetic Scaffolds with Well-Defined Pore Geometry by Fused Deposition Modeling**"; Google Patents, 2010.

Resumen

A method for fabrication of a scaffold by fused deposition modeling is provided. The method includes forming a sacrificial mold with fused deposition modeling, the sacrificial mold comprising a dissolvable material. The method further includes infusing the sacrificial mold with a biodegradable composition and applying a solvent to the biodegradable composition infused sacrificial mold to dissolve the sacrificial mold and leave a scaffold formed from the biodegradable composition.

18. Schulman, M.L. and Panzera, C., "**Mass production of shells and models for dental restorations produced by solid free-form fabrication methods**"; Google Patents, 2004.

Resumen

Solid free form fabrication techniques such as fused deposition modeling and three-dimensional printing are used to create a shell used in the manufacture of a dental restoration. Three-dimensional printing includes ink-jet printing a binder into selected areas of sequentially deposited layers of powder. Each layer is created by spreading a thin layer of powder over the surface of a powder bed. Instructions for each layer may be derived directly from a CAD representation of the restoration. The area to be printed is obtained by computing the area of intersection between the desired plane and the CAD representation of the object. All the layers required for an aesthetically sound shell can be deposited concurrently slice after slice and sintered/cured simultaneously. While the layers become hardened or at least partially hardened as each of the layers is laid down, once the desired final shaped configuration is achieved and the layering process is complete, in some applications it may be desirable that the form and its contents be heated, cooled or cured at a suitably selected temperature to further promote the integrity of solid free-form structures.

19. MacDougald, J.A., Panzera, C., Jia, W., Brodkin, D., Schulman, M.L., Panzera, P. and Alpert, B., "**Method for manufacturing dental restorations**"; Google Patents, 2003.

Resumen

A ceramic tape is provided in its green state so that it is malleable and formable to a mold for forming a dental restoration, but will not break or crack as it is applied to the mold. Pressure may be applied to further form or adapt the ceramic tape to the shape of the mold. Heat is applied simultaneously with pressure or in a separate step to achieve high density and strength in the ceramic material. A vacuum atmosphere may be used with the application of pressure and/or heat. One or more layers of surface material such as porcelain or composite resin may be applied to the ceramic to form the dental restoration. The process is useful in the manufacture of dental materials or restorations including but not limited to orthodontic appliances, bridges, space maintainers, tooth replacement appliances, splints, crowns, partial crowns, dentures, posts, teeth, jackets, inlays, onlays, facing, veneers, facets, implants, abutments, cylinders, and connectors.

Also provided is a ceramic powder in combination with one or more media materials to form a homogeneous mixture. The mixture may then be used to form a dental restoration as is or may be used to form feedstock such as filaments or wires which are then used to fabricate a dental restoration. The filaments or wires may be used in a fused deposition-modeling machine to build dental restorative materials by computer aided design software.

20. Hall, T.L., Maxwell, A., Cain, C.A., Kim, Y. and Xu, Z., "**Ultrasound Transducer Manufacturing Using Rapid-Prototyping Method**"; Google Patents, 2013.

Resumen

An ultrasound therapy system is provided that can include any number of features. In some embodiments, the custom transducer housings can be manufactured using a rapid-prototyping method to arrange a plurality of single-element, substantially flat transducers to share a common focal point. The rapid-prototyping method can include, for example, fused-deposition modeling, 3D printing, and stereolithography. In some embodiments, the therapy system can include a plurality of transducer modules insertable into the openings of the transducer housing. Each transducer module can include an acoustic lens, a substantially flat, single-element transducer, and a matching layer disposed between the lens and the transducer. Methods of use and manufacture are also described.