

UK Patent Application GB 2511316

(13) A
03.09.2014

(21) Application No: 1303468.1

(22) Date of Filing: 27.02.2013

(71) Applicant(s):
MCOR Technologies Limited
Unit 1, IDA Business Park, Ardee Road, Dunleer,
Co Louth, Ireland

(72) Inventor(s):
Philip Keenan
Conor MacCormack
Fintan MacCormack

(74) Agent and/or Address for Service:
Hanna Moore & Curley
13 Lower Lad Lane, Dublin 2, Ireland

(51) INT CL:
B29C 67/00 (2006.01)

(56) Documents Cited:
GB 2323553 A US 6146487 A
US 20040045661 A1

(58) Field of Search:
INT CL **B29C, B32B**
Other: **EPODOC, WPI**

(54) Title of the Invention: **Tack and bond adhesive system and method for layered object manufacture**
Abstract Title: **Layered object manufacture using two adhesive types**

(57) An adhesive dispensing device for use in a Layered Object Manufacturing (LOM) system for forming a three-dimensional (3D) object is configured to apply adhesive to an object media layer comprising a temporary region 105 and a permanent region 110. A first adhesive 1 is applied to temporary regions 105 and a second adhesive 2 is applied to permanent regions 110. After completion of the layered object, the first adhesive may be de-bonded by, for instance, the application of heat, thereby facilitating the removal of the temporary material. Further provided are first and second adhesive formulations, a bonding module for bonding a plurality of individual object media layers using the first and second adhesives, and a LOM system comprising the bonding module.

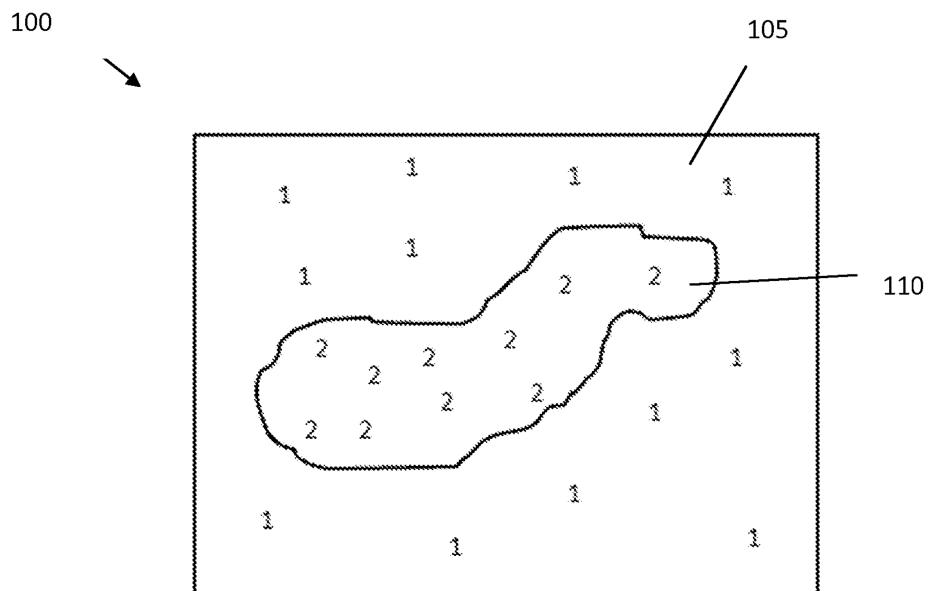


Figure 2

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

GB 2511316 A

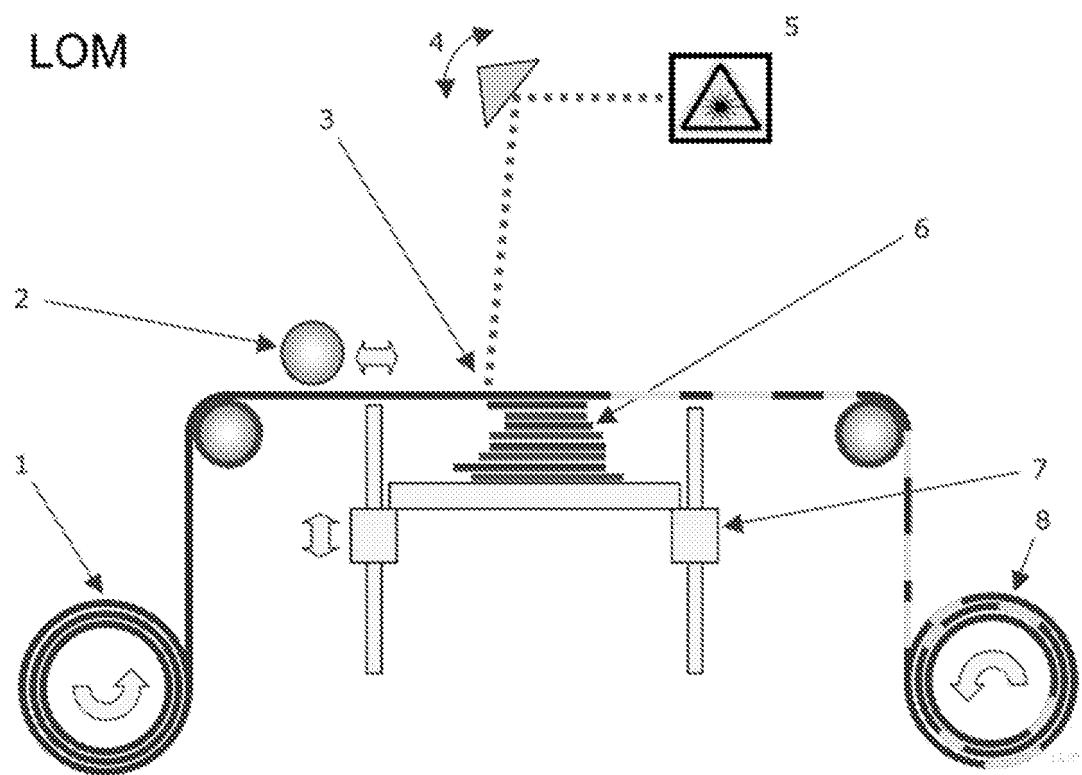


Figure 1

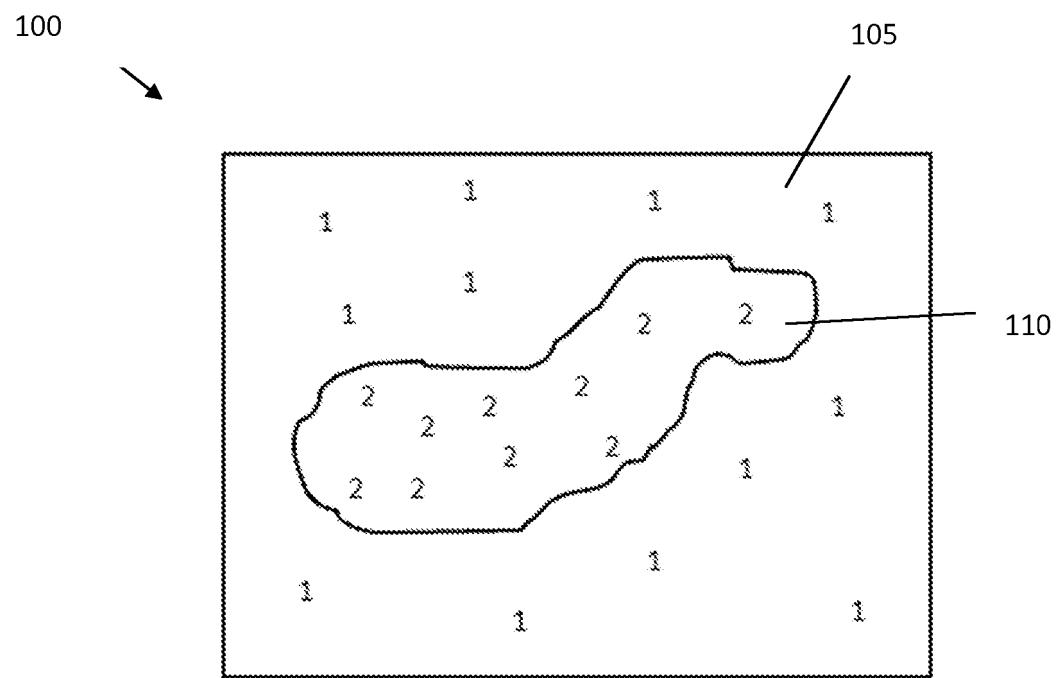


Figure 2

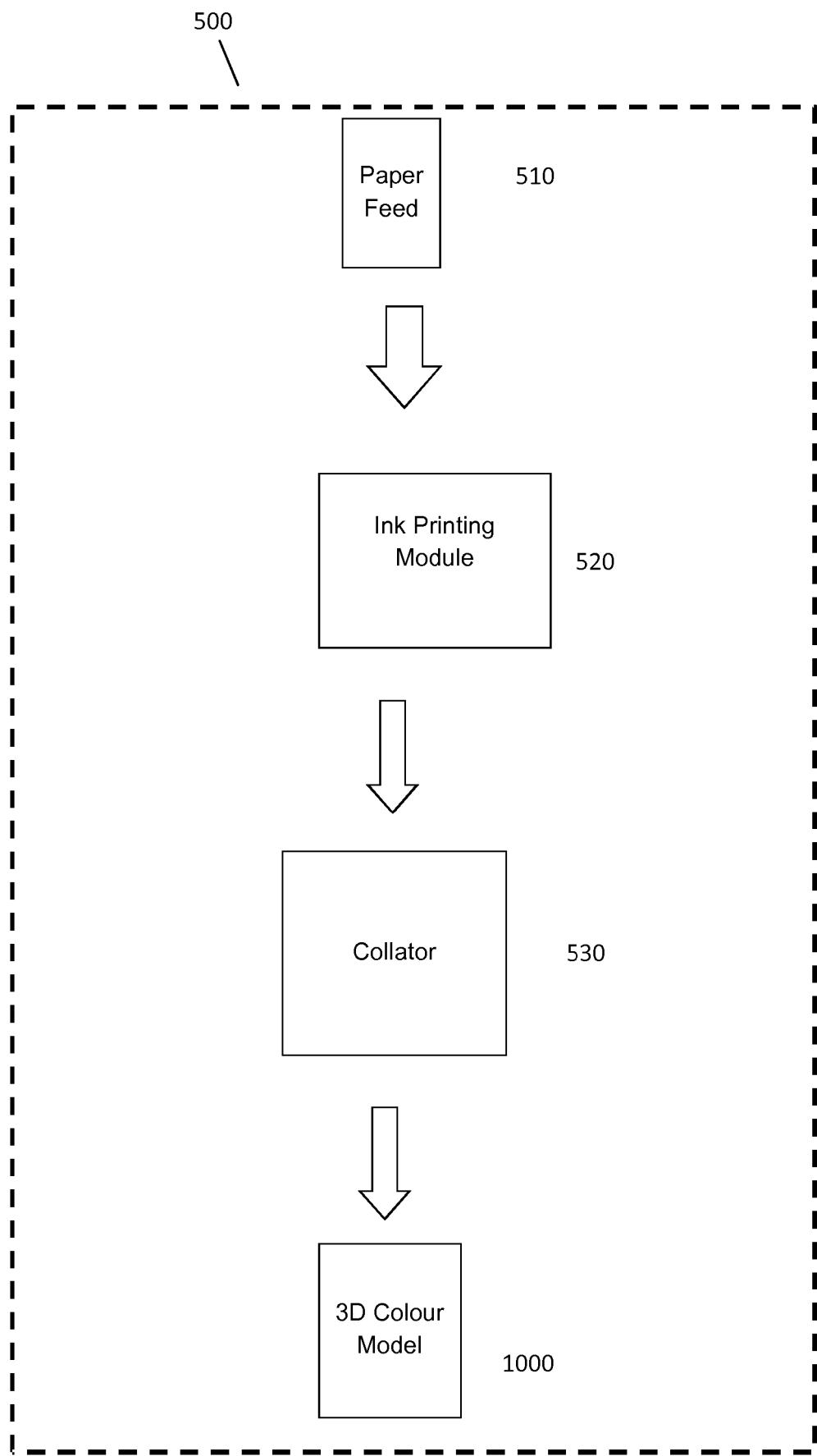


Figure 3

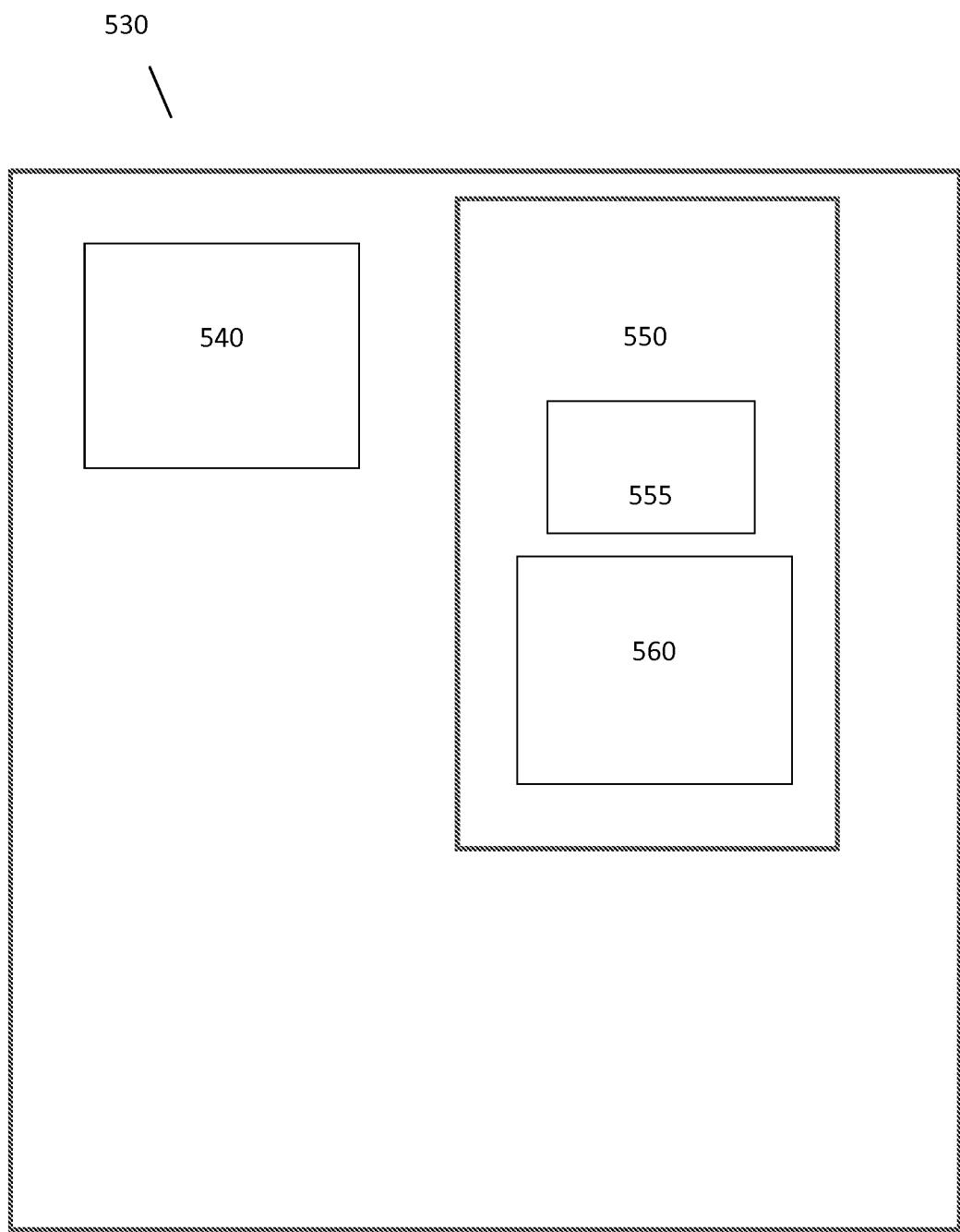


Figure 4

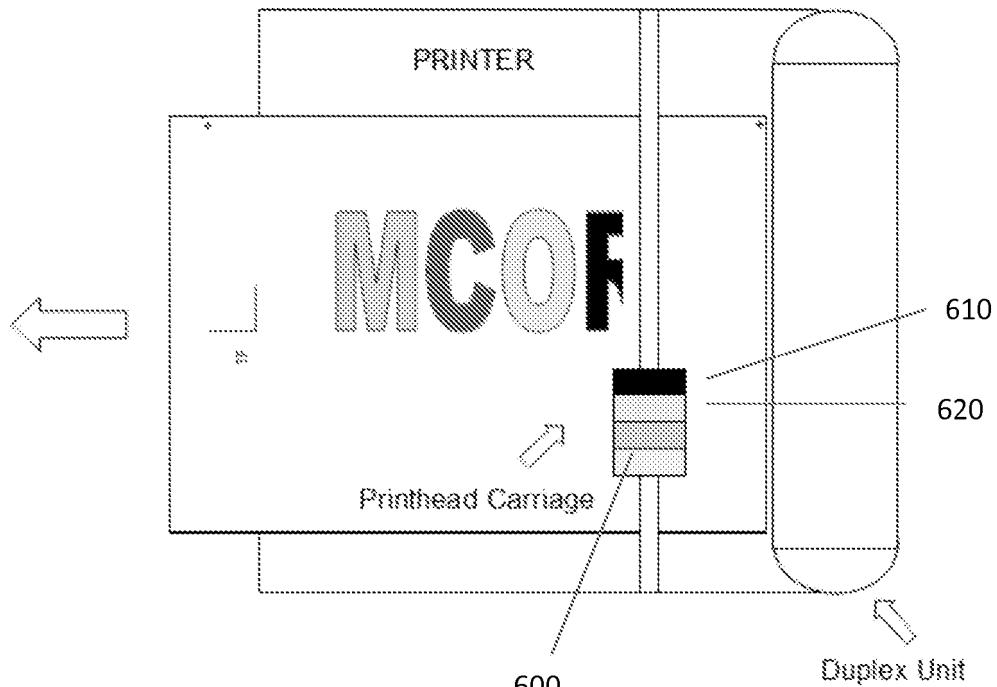


Figure 5

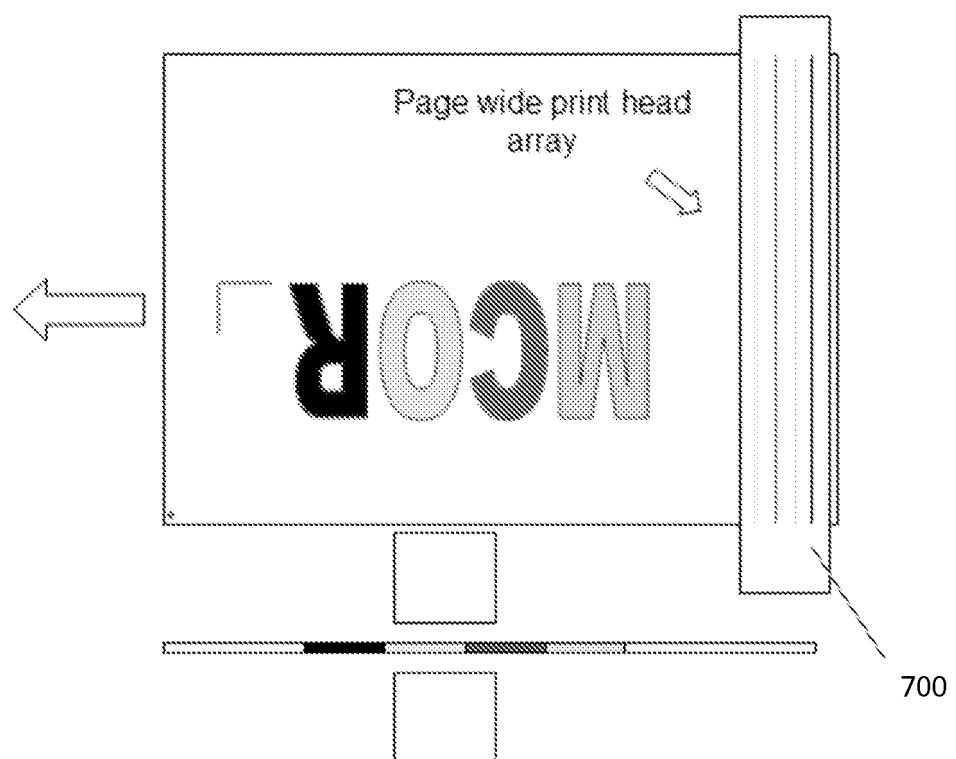


Figure 6

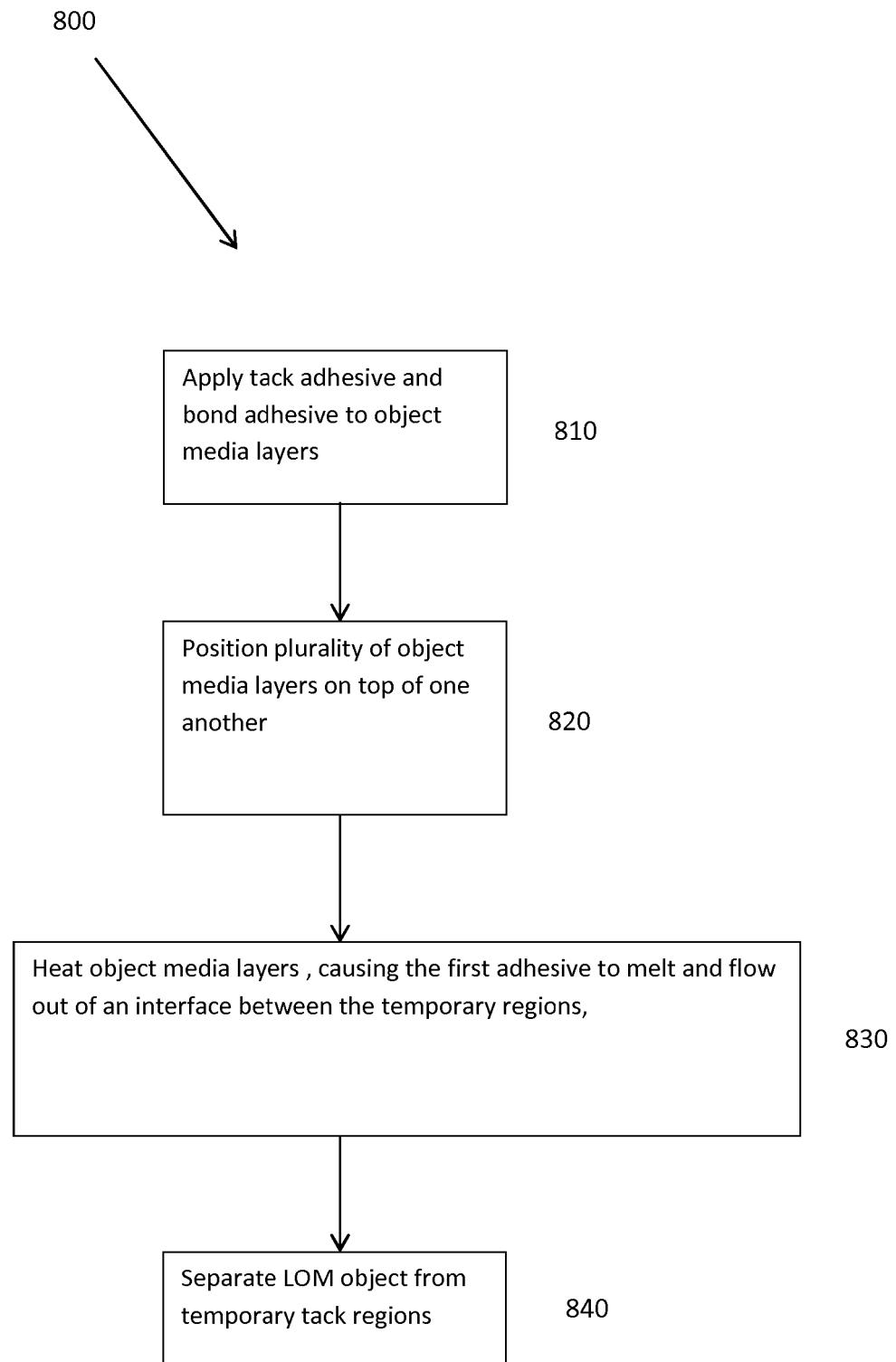


Figure 7

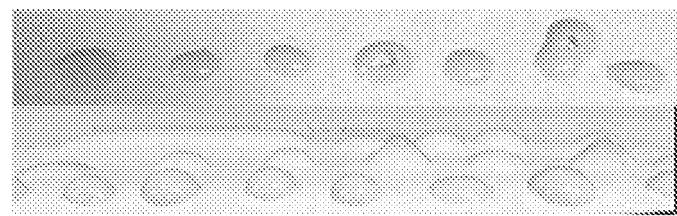


Figure 8

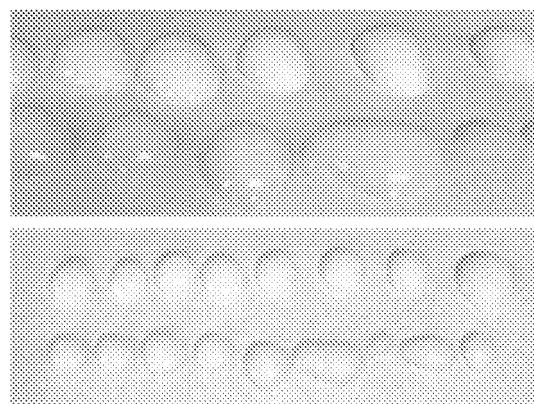


Figure 9

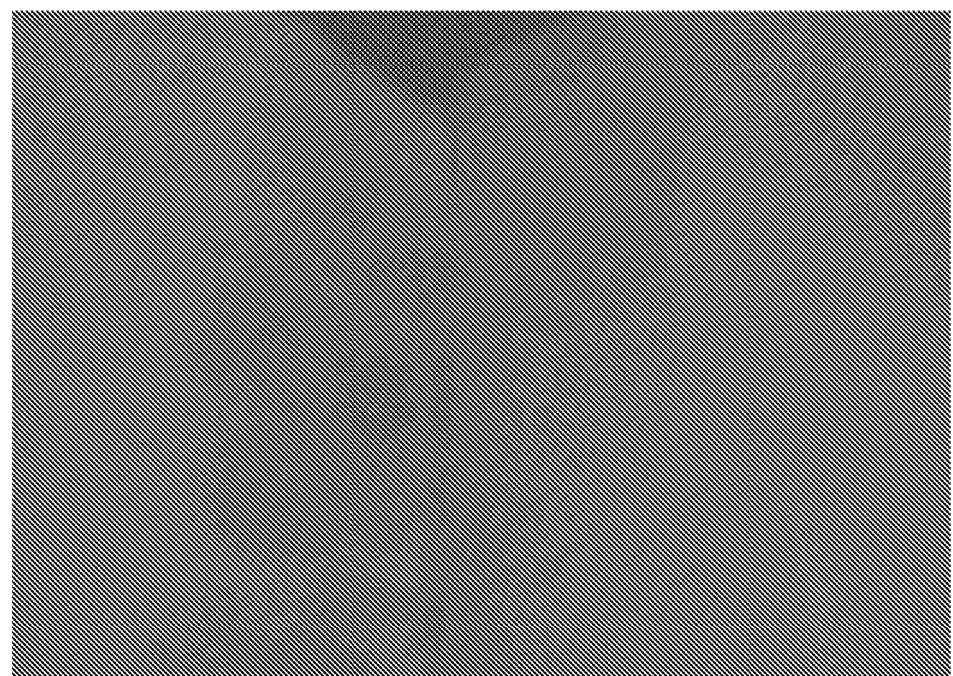


Figure 10

23 04 14

Title

Tack and Bond Adhesive System and Method for Layered Object Manufacture

Field

- 5 The present application relates to Laminated or Layer Object Manufacturing (LOM), and in particular to devices and in particular a tack and bond adhesive system and method for for Layered Object Manufacture.

Background Of The Invention

- 10 Rapid prototyping is defined as computer-controlled additive fabrication, in that an object can be fabricated by the addition of material rather than conventional machining methods that rely on removal or the subtraction of material. The term “rapid” is, it will be appreciated, a relative term but one that has specific meaning within the art, in that construction of a finished three dimensional
15 articles can take from several hours to several days, depending on the method used and the size and complexity of the model. There are many known methodologies that are employed within the general field of rapid prototyping
Layered Object Manufacture (LOM) is one form of Rapid prototyping (RP) which relates to the successive layering of adhesive-coated paper, plastic, or metal
20 laminates which are then successively glued together and cut to shape with a knife or laser cutter.

- 25 After a plurality of media object layers are formed, a profiling and layer bonding process is performed. The plurality of layers are bonded together, and then a profiling or weeding process is performed which comprises removing unwanted support material from the printed media stack to reveal the 3D printed object.

- 30 In LOM rapid prototyping, there are initially two regions of the LOM object. That is, the LOM object comprises permanent regions where the layers are bonded together to constitute the final 3D object, and a temporary regions subsequently “weeded” to separate and remove them from the final 3D object. In typical LOM

manufacturing, adhesive is pre-applied to the media on a roll. Figure 1 is a diagram illustrating a conventional LOM assembly process in which adhesive is pre-applied to the media on a roll 1. The adhesive is activated by a heated roller 2 to cause layers 6 in contact to bond together. A laser unit 5 irradiating a laser 5 beam 3 via a prism 4 facilitates removal of waste material.

In existing LOM systems that employ paper based raw materials, the paper is provided in the form of a roll. The roll of paper may be provided with adhesive already present on the underside. In this case, the adhesive may be activated 10 by heat and/or pressure to form a bond onto the previous layer. In an alternative approach, adhesive may be applied to the underside of the material as it is drawn from a roll. However, there are a number of disadvantages associated with the use of roll material. For example, a machine is often operable only with specifically manufactured rolls of material, which may be expensive to obtain 15 and/or difficult to replace. There are also disadvantages associated with the day to day use of rolls of raw material. For example, the rolls may become stuck or jammed in the feeding mechanism due to the pre-applied adhesive thereon. With the above, removal of the waste material can be very difficult because it is adhered together with the same adhesive force as the part being 20 made. This can lead to the part being damaged during waste removal “weeding”, as chisels and other sharp implements are often needed to prise the object free.

In US 2011/0094441 A1 adhesive is applied to the media by using a wheel with 25 dimples filled with adhesive which is then brought in contact with the substrate to transfer controlled amounts of adhesive at discrete points on the substrate. This system is able to digitally apply a higher glue dot printing density in the permanent bonded regions of the LOM assembly, and a lower density of dots in the temporary support regions.

30

Other methods of applying adhesive between paper layers include: coating the entire working area of the sheet, which as noted above produces significant

difficulties when removing waste material during post processing the finished part; and using a substance which when placed in certain locations on the sheet prevents adhesion at these locations. This technique has the disadvantage of effectively wasting adhesive by initially coating the entire sheet.

5

It is further noted that current LOM systems often use adhesives that are solvent based and which are not water soluble and thus present environmental issues for example, for the purposes of disposal. However, such solvent based adhesive have to date been used in LOM as the use of water-based adhesives 10 having a high wet content presents further problems such as warping and distortion of the paper which has prejudiced their application in LOM systems.

Thus, there are a number of problems associated bonding and with removal of waste material in LOM systems for rapid prototyping that need to be addressed.

15

Summary

Accordingly, the present teaching provides an adhesive dispensing device as detailed in claim 1.

20 According to another aspect there is provided an LOM system for application of first and second adhesives to different regions of object media layers of an object as provided in claim 10. Also provided is a first adhesive for temporarily bonding temporary regions of a plurality of object media layers according to claim 15. Further provided is a second adhesive for permanently bonding bond 25 regions of a plurality of object media according to claim 23. The application also provides a bonding module in accordance with claim 32. Also provided is a LOM system comprising a collator in accordance with claim 38. Also provided is a method according to claim 41. Advantageous features are provided in the dependent claims.

30

Brief Description Of The Drawings

The present application will now be described with reference to the accompanying drawings in which:

- Figure 1 is a diagram illustrating a conventional LOM assembly process in which adhesive is pre-applied to the media on a roll, wherein the adhesive is activated by a heated roller to cause layers in contact to bond together;
- 5 Figure 2 is a diagram illustrating tack and bond adhesive regions in a media layer of a LOM object;
- Figure 3 is a block diagram of a Layer Object Manufacturing (LOM) system according to the present teaching;
- 10 Figure 4 is a block diagram of a collator module according to an embodiment of the present teaching;
- Figure 5 illustrates a typical print head carriage that is configured to scan across the width of an object media layer when printing ink or adhesive;
- Figure 6 illustrates a page-wide array print head;
- 15 Figure 7 is a flowchart illustrating a process of bonding a plurality of individual object media layers to form a three-dimensional (3D) object in a Layered Object Manufacturing (LOM) system, according to an embodiment of the present teaching.
- Figure 8 is a photographic image of a wax microemulsion in water printed onto paper;
- 20 Figure 9 is a photographic image of an ethylene vinyl acetate (EVA) microemulsion printed onto paper; and
- Figure 10 is a photographic image of an example of a bonded region paper failure after attempting to separate two layers after bonding and thermally laminating.
- 25

Detailed Description Of The Drawings

The words comprises/comprising when used in this specification are to specify the presence of stated features, integers, steps or components but does not

- 30 preclude the presence or addition of one or more other features, integers , steps, components or groups thereof.

Referring to the drawings and initially Figs. 2 to 4 a Layered Object Manufacturing (LOM) system for forming a three-dimensional (3D) object is provided. The system comprises an adhesive dispensing device 560.

- 5 Figure 2 is a diagram illustrating tack and bond adhesive regions in an object media layer 100 of a LOM object. Referring to Fig. 2, an object media layer 100 of an LOM object 1000 includes different regions namely temporary regions 105, being those regions which are to be removed or weeded in the process of forming the three-dimensional object 1000, and permanent regions 110 which
- 10 are layer built and bonded to form the final three-dimensional object 1000.

In the present specification, two different types of adhesive 400 are provided for use in the process of forming an LOM object. A first adhesive 405 is applied to temporary regions for tacking the temporary regions 105 (regions to be weeded) 15 and a second adhesive 410 is applied to the permanent regions 110 for bonding permanent regions 110 of a plurality of 3D object media layers.

Referring to Figures 2 to 4, the system and adhesive dispensing device is configured to apply adhesive to the object media layer 100, comprising applying 20 the first adhesive 405 to temporary regions 105 of the object media layer 100 and the second adhesive 410 to permanent regions 110 of the object media layer 100.

The first adhesive 405 is provided for temporarily bonding or tacking temporary 25 regions 105 of a plurality of object media layers 100 in a Layered Object Manufacturing (LOM) system for forming a three-dimensional (3D) object is provided. The first adhesive 405 provides a bonding of media layers 100 when applied thereto. The first adhesive 405 provides bonding in a temperature range including room temperature and operation temperature of the system device.

30 The first adhesive 405 provides bonding at normal room or air or operating pressures. The first adhesive is a tacking adhesive 405. The weeding of temporary regions of the object is facilitated and eased by use of the temporary

or tacking adhesive. The tacking adhesive is configured to provide temporary bonding. The tacking adhesive is configured to become inactive as a bonding agent and/or to release the bond, and/or to be removed, when required. The tacking adhesive is deactivatable and/or releaseable and/or removable when it

- 5 is no longer required that the temporary regions 105 be bonded together. The tacking adhesive 405 when deactivated or inactive or released or removed no longer provides bonding of temporary regions. The tacking adhesive 405 becomes inactive or is removable for the step of weeding temporary regions 105 of a build object.

10

In a preferred example arrangement according to an embodiment of the present specification, the tacking adhesive 405 is configured to be deactivated or removed upon application of heat above a predetermined temperature. The tacking adhesive 405 is configured to melt and flow out of an interface between

- 15 the temporary regions 105 of the media layers 100 upon the application of heat to the plurality of object media layers 100 to which adhesive 405 has been applied. The tacking adhesive 405 is configured to melt and flow out of an adhesive interface between temporary regions 105 of the object media layers when the plurality of adhesive printed object media layers are heated above a
- 20 predetermined temperature.

It will be appreciated that while the application of heat or a predetermined minimum is used to deactivate or remove the tack adhesive other alternative arrangements may be used. For example the adhesive 405 may be configured

- 25 to be deactivated on the application of a low temperature or on application of a predetermined pressure. Alternatively another suitable deactivation method may be provided.

According to the present specification a second adhesive is provided for

- 30 permanently bonding bond regions 110 of the plurality of object media layers 100. The second adhesive is a bond or permanent bond adhesive. The bond regions 110 which are bonded together using the second permanent bond

adhesive remain bonded when heat above a predetermined temperature is applied. In one arrangement the second permanent bond adhesive is not affected by the application of heat to release the bond of the tacking adhesive. In another arrangement the bond of the second adhesive may be increased on application of heat. The bond may become stronger upon application of heat above a predetermined temperature

5 Referring to Fig. 3, the system comprises a layer bonding module 550 for bonding the plurality of individual object media layers to form a 3D object in a
10 LOM system. Each object media layer comprises a temporary region 105 to which the first tacking adhesive 405 is applied and a permanent region 110 to which the the second bond adhesive 410 is applied.

15 Referring to Figure 4, the layer bonding module 550 may comprise a heating element 555 for heating the plurality of adhesive printed object media layers 100.

20 Referring to Figs 2, 3 and 4 the operation of a Layered Object Manufacturing (LOM) system according to the present specification to assemble a plurality of individual printed media layers 100 to form a three-dimensional (3D) object is described. The system comprises a collator configured to assemble the plurality of the individual printed media layers, the collator comprising the adhesive dispensing device and the bonding module. The LOM system may further comprise a printing module such as an ink printer for printing the plurality of
25 object media layers 100 before collation. Figure 3 is a block diagram of a Layer Object Manufacturing (LOM) system 500 according to an embodiment of the present teaching.

30 In Figure 3, media such as paper may be fed into a printing module 520 via a paper feed mechanism 510. The media may be printed with ink or the like in the printing module 520. The plurality of object media layers 100 are then profiled

and bonded in a collator module 530 to produce a completed colour 3D object 1000.

Figure 4 is a block diagram of the collator module 530 according to an 5 embodiment of the present teaching. Referring to Figure 4, the collator module 530 may comprise a separate profiling module 540 and a layer bonding module 550 respectively. The layer bonding module 550 may comprise an adhesive dispensing device 560 according to the present teaching and a heating element 555 for heating the plurality of adhesive printed object media layers 100.

10

Within the context of the present teaching, the individual media layers 100 may be considered distinct physical elements or entities. In this way they may be individually picked and placed or otherwise transported within the system. The LOM system may 500 comprise the printing module 510 configured to print a 15 plurality of media layers 100, and the collator module 530 configured to assemble the plurality of the individual media layers 100 to form the 3D object 1000. Each of the individual media layers 100 may be individually or independently printed. The collator module 530 may comprise profiling and layer bonding modules 540 and 550 for cutting the individual 3D object media 20 layers and bonding the individual layers together to form the finished 3D object 1000.

The printing module 520 may be provided in a separate processing module from the collator 530 or may be integral.

25

The collator module 530 may comprise a layer bonding module 550 configured to bond individual ones of the plurality of media layers 100. The layer bonding module 550 may be configured to use an adhesive 400 to bond the layers 100 together. The adhesive is dispensed using the adhesive dispensing device 560 30 according to the present teaching. The collator module 530 may also comprise a profiling module 540 configured to effect a profiling of individual ones of the plurality of media layers 100 to effect a desired 3D shape within the 3D object

1000. The profiling module 540 and the layer bonding module 550 may be integrated in a single profiling and layer bonding module within the collator module 530.

- 5 The printing module 520 may be an office printer that has large capacity input and output trays and comes with duplex units as standard. The printing module 520 may also be integrated with the collator module 530, such that the printing process immediately precedes the profiling and bonding processes.
- 10 The present specification provides a system and method for bonding and profiling, and particularly a bonding method for bonding individual ones of the plurality of object media layers 100 to one another. As mentioned above, in LOM rapid prototyping, there are initially two regions of the LOM object. That is, the LOM object comprises a permanent bond region 110 where the layers are bonded together to constitute the final 3D object 1000, and a temporary tack region 105. The tack regions 105 are subsequently “weeded” to separate and remove them from the final 3D object 1000. The present teaching provides for different adhesives to be applied to the temporary region 105 and the permanent region 110 of each of the object media layers 100.
- 15
- 20 The two different types of adhesive 400 comprise the tack adhesive 405 and the bond-adhesive 410. The purpose of the tack adhesive 405 is to temporarily bond or tack the layers 100 together during lamination and cut processes such that the action of the cutting process does not disturb the layer being cut. i.e., prevent the cut layer from lifting or tearing during cutting. Once the LOM process is complete, the tack adhesive 405 may be removed by subsequent processing which will be explained later. The temporary regions 105 are indicated in Figure 3 with the “1” character.
- 25
- 30 The purpose of the bond adhesive 410 is to permanently bond the object media layers 100 to one another. The bond is preferably sufficiently strong such that the layers 100 do not separate from one another during the weeding process,

and in subsequent handling of the 3D object 1000. The permanent regions 110 are indicated in Figure 2 with the “2” character.

5 The system and method of the present specification provides that both the temporary tack adhesive 405 and permanent bond adhesive 410 may be co-printed simultaneously using the adhesive dispensing device 560 according to the present teaching.

10 The adhesive dispensing device 560 may comprise control means to enable the discriminatory application of specific volumes of adhesive 405, 410 at specific locations on the object media layer 100. This enables the controlled dispensing of adhesive to specific locations which advantageously allows for reduced volumes of adhesive to be used and also ensures that the adhesive is applied specifically at the locations where the adhesive is required.

15 In this regard, the adhesive dispensing device 560 may comprise an adhesive printer configured to print the tack adhesive 405 and the bond adhesive 410 at specific locations 105, 110 on the object media layer 100. The adhesive dispensing device 560 may be configured to apply or print specific controlled 20 volumes of the adhesives to the target locations 105 and 110. The volumes may be adjustable.

As mentioned above, the present teaching provides an adhesive dispensing device for use in layered object manufacturing (LOM) systems for rapid 25 prototyping. Referring to Figure 4, the adhesive dispensing device 560 according to the present teaching may be included in the collator module 530. The adhesive dispensing device 560 provides for the application of adhesive to a 3D object media layer 100. The device 560 is configured to apply a first adhesive 405 for tacking temporary regions 105 of the 3D object media layer 30 100 and a second adhesive 410 for bonding permanent regions 110 of the 3D object media layer 100. The adhesive dispensing device 560 may comprise one or more inkjet printheads. Preferably the device comprises a single printhead

provided with the ability of printing two or more fluids simultaneously. The printhead does not make contact with the object media layer 100 and may be scanned back and forth at speed to rapidly deposit one or more layers of adhesive onto the substrate. The printhead may comprise a print head carriage

- 5 that is configured to scan across the width of an object media layer 100 when dispensing adhesive. Alternatively, the printhead may comprise a page-wide array print head. Figure 5 illustrates a typical print head carriage 600 that is configured to scan across the width of an object media layer 100 when printing ink or adhesive. Referring to Figure 5, the print head carriage 600 may be
- 10 configured to dispense a first tack adhesive 605 and a second bond adhesive 610. Figure 6 illustrates a page-wide array print head 700 that may also be configured to dispense a first tack adhesive 605 and a second bond adhesive 610.
- 15 The adhesives 405, 410 used for both the tacking and bonding may be preferably formulated to be suitable for inkjet printing. The adhesives may be configured such that the viscosity of the adhesive is generally less than 50 cP, and preferably in the range of 1 – 10 cP. The surface tension of the adhesives is preferably greater than 34 dyne/cm so that it is rendered less liable to wick
- 20 through a porous surface of the object media layer and result in less of the adhesive being available at the surface for bonding.

It will be appreciated that different formulations of a tacking adhesive according to the present specification may be provided.

25

The tack adhesive 405 has been formulated taking account of issues and features including the following:

- The adhesive may be formulated so that when it is heated above its melting point it becomes a liquid
- 30 - The adhesive may have a sufficiently low viscosity to allow it to be inkjet printed
- The adhesive may comprise wax

- The wax may be selected according to the desired post-processing temperature
 - The adhesive may comprise a microemulsion
 - The adhesive may comprise a microemulsion of wax particles in deionised water
- 5
- The adhesive may further comprise stearic acid
 - The tack adhesive may further comprise glycol
 - The adhesive may have a relatively high surface tension when deposited onto cellulose-based paper
- 10
- The adhesive is suitable for printing
 - The adhesive is suitable for printing using an inkjet printhead

According to preferred exemplary arrangement of embodiments of the present specification different types of tack adhesive may be used including the
15 following:

a) 100% Solid Wax Formulation

The tack adhesive may comprise a single solid wax such as beeswax. The wax may be formulated so that when it is heated above its melting point it becomes
20 a liquid and has a sufficiently low viscosity to allow it to be inkjet printed.

b) Microemulsion of Wax Particles in Water

The tack adhesive may alternatively comprise a microemulsion of wax particles in deionised water. This formulation may be simpler to implement as it does not
25 require elevated ink temperatures. In order to form the microemulsion, 100g of deionised water may be heated to 90 ° C and 60 grams of solid wax flakes may be added thereto. The mixture may then be agitated using a high-shear mixing blade at around 10,000 rpm for 60 seconds, and then the mixture is allowed to cool. The wax may be selected according to the desired post-
30 processing temperature. In this regard, the wax may comprise paraffin wax, beeswax, or Carnauba wax. A table showing the melting points of these waxes is provided as follows:

Type	Melting Point (deg C)
Paraffin	46-68
Beeswax	62-64
Carnauba	82-86

The result is the creation of a microemulsion of wax particles in a matrix of deionised water.

5

The microemulsion may further comprise stearic acid. The addition of stearic acid may adjust the pH of the microemulsion to between pH 10-11, thereby stabilizing the microemulsion, and preventing creaming, agglomeration or sedimentation of the wax particles.

10

The tack adhesive may further comprise glycol. The effect of the addition of glycol is that a printhead used for dispensing the adhesive can be left uncapped for a longer period of time. Glycol also improves the performance of the tack adhesive in a printhead. That is, the adhesive may remain in the printhead nozzles for a longer period without drying out.

In experiments conducted, a Carnauba wax emulsion was measured for inkjet printable properties. The viscosity of the emulsion was 4.76 mPas and the surface tension was 35.42 mN/. The resultant wax microemulsion adhesive had

20

a relatively high surface tension when deposited onto cellulose-based paper and produced a contact angle of around 70 ° C. Figure 8 is a photographic image of a wax microemulsion in water printed onto an object media layer in the form of paper.

25

As mentioned above, the wax microemulsion may be printed using a conventional inkjet printer that is designed with two ink fluid pathways by scanning the printhead across the paper media. The wax microemulsion may be deposited onto the object media layer where it is retained as sphere-like drops. Water will immediately begin to evaporate from the micro emulsion drops

30

and the wax particles will begin to coalesce and form small disks approximately

50 microns in diameter and 20 microns high (based on an initial drop volume of 28 picolitres).

- The bond adhesive formulation may be obtained by diluting an ethylene vinyl acetate (EVA) co-polymer glue emulsion and with deionised water. The ratio may be 1 part glue to 9 parts of water. The mixture may then be agitated thoroughly. This results in a microemulsion of EVA particles in water, and approximately 5% EVA solids in water. The viscosity of this solution was measured to be 1.66 mPas and the surface tension thereof was measured to be 53.65 mN/m. Accordingly, the resultant microemulsion had a high surface tension and produced a wetting angle of approximately 80 ° when printed onto cellulose-based paper. Figure 9 is a photographic image of an EVA microemulsion printed onto paper.
- 15 Figure 7 is a flowchart illustrating a method or process 800 of bonding a plurality of individual object media layers to form a three-dimensional (3D) object in a Layered Object Manufacturing (LOM) system, according to an embodiment of the present teaching. The plurality of object media layers 100, which may have been previously printed with ink or the like, each comprise a tack or temporary region 105 and a bond region 110 as described previously. Referring to Figure 7, the tack adhesive 405 and the bond adhesive 410 are applied 810 to the temporary region 105 and permanent region 110, respectively. The adhesives may be applied using the adhesive dispensing device 560 described previously. The object media layers 100 are positioned on top of one another 820. The object media layers 100 may be positioned on top of one another as adhesive is applied to each layer. In this way, object media layers 100 may be positioned on top of object media layers 100 to which adhesive has previously been applied. Then the plurality of object media layers 100 are heated 840. A build table of the bonding module 550 may be raised to press the object media layers 100 against a heating element and retained in this position to allow the heat to penetrate the layers. The heating element 555 may comprise a hotplate. The entire LOM layer stack comprising the plurality of object media layers 100 may

be heated above the melting point of the tack adhesive 405, causing the tack adhesive 405 to flow 840, and leave the temporary tack region interface. In this way, the temporary regions 105 of the object media layers 100 are not adhered together, which facilitates the separation or weeding process performed

- 5 subsequently. Finally, the completed LOM object comprising the bonded permanent regions 110 is separated 840 from the tacked/released temporary regions 105.

By retaining the LOM layer stack at an temperature of about 90 °C such that the

- 10 inner core of the LOM stack and the outer environment achieve a uniform temperature, the permanent bond adhesive regions 110 tend to strengthen with further loss of water at the elevated temperature.

On the other hand, the first tack adhesive 405 melts to become a low viscosity

- 15 liquid, and migrates away from the printed regions by capillary action. The first tack adhesive 405 may generally move in a direction away from the permanent bond region 110 already occupied by the permanent bond adhesive 410.

The result is that the layers 100 in the tack regions 105 lose all structural

- 20 integrity and tend to auto-separate, or to self-weed and separate from the permanently bonded object 1000.

Retaining the glued layers in contact with a surface heated to 80 °C for two seconds may cause the wax in the tack adhesive 405 to partially melt and flow.

- 25 On removing the layers from the heat source the wax may re-solidify to form a bond between the two layers. The bond adhesive layers create a much stronger bond force. Experiments have shown that if the bond adhesive layers are pulled apart paper fibres in the bond regions may tear. i.e. the paper itself may fail before the glue bond fails. Figure 10 is a photographic image of a bonded
- 30 region paper failure after attempting to separate two object media layers after bonding and thermally laminating.

A method of bonding a plurality of individual object media layers to form a three-dimensional (3D) object in in a Layered Object Manufacturing (LOM) system, each object media layer comprising temporary regions and permanent regions

5 comprising:

applying a first tack adhesive to the temporary regions of each of a plurality of object media layers;

applying a second bond adhesive to the permanent regions of each of the plurality of object media layers;

10 positioning the object media layers on top of each other to form the object;

heating the object media layers above a predetermined temperature causing the first adhesive to melt and flow out of an interface between the temporary regions

15 separating the temporary regions from the LOM object.

Heating the object media layers above a predetermined temperature causes the second bond adhesive to bond the permanent regions permanently to form a completed LOM object.

20

The heat is applied to heat the object media layers to a temperature above the melting point of a wax used in the first adhesive. In a preferred arrangement according to the present specification the heating step includes heating the object media layers to a temperature above 80 °C. Heating of the first adhesive

25 causes capillary flow of the first adhesive and causing a debonding of the temporary regions of the object media layers. In a preferred arrangement according to an embodiment of the present specification, the first adhesive is a temporary adhesive and the object media layers comprise sheets of paper and heating causes the capillary flow of the first temporary adhesive causing a
30 debonding of the paper sheets.

The terms media, object media layers and layers have been used interchangeably. The terms refer to the substrate that is being used in the 3D fabrication process. In a preferred arrangement of the present application this is paper or cellulose paper. However, it will be appreciated that other media

- 5 types could be employed, and may include, polymer film, metal foils, ceramic powder impregnated paper sheets, metal powder impregnated sheets, polymer powder impregnated sheets, water soluble papers, substrates made from waxes etc.
- 10 The present teaching overcomes the problems of removing temporary support materials from a permanently bonded LOM object. This is achieved by using a temporary adhesive which is configured to release the temporary regions or temporary support layers of a build object when the entire LOM layer stack is heated above the melting point of the tack adhesive. This causes the tack
- 15 adhesive to flow, and leave the temporary support layer interface. The present teaching advantageously eliminates the need to use force to tear away the temporary support structures to reveal the LOM object. Further, the bonding module of the present teaching is advantageously configured to speed up the process required to separate the LOM object from its support material. The
- 20 present teaching also reduces the likelihood of damaging the LOM object during weeding, or inadvertently removing LOM object material.

While the present invention has been described with reference to some

exemplary arrangements it will be understood that it is not intended to limit the

- 25 teaching of the present invention to such arrangements as modifications can be made without departing from the spirit and scope of the present invention. In this way it will be understood that the invention is to be limited only insofar as is deemed necessary in the light of the appended claims.

CLAIMS

1. An adhesive dispensing device for use in a Layered Object Manufacturing (LOM) system for forming a three-dimensional (3D) object by application of adhesive to a plurality of object media layers, each object media layer comprising a temporary region and a permanent region, wherein the device configured to apply a first adhesive to a temporary region of an object media layer and a second bonding adhesive to a permanent region of the object media layer.
- 5 2. The device of claim 1, comprising one or more printheads.
- 10 3. The device of claim 2, wherein the one or more printheads are configured to co-print the first and second adhesives simultaneously.
- 15 4. The device of claim 3, comprising a single printhead.
5. The device of any of claims 2 to 4 wherein the printhead or printheads comprise an inkjet printhead.
- 20 6. The device of any of the preceding claims, wherein the device is configured to apply the adhesive spaced apart from the 3D object media layer.
7. The device of any of claims 2 to 6, wherein each of the printheads comprises a printhead carriage that is configured to scan across the width of an object media layer when printing the adhesive.
- 25 8. The device of any of claims 2 to 7, wherein each of the printheads comprises a page-wide array print head.
- 30 9. The device of any of claims 1 to 8, being configured to print predefined volumes of the first adhesive and the second adhesive at specific locations on the object media layer

10. A Layered Object Manufacturing (LOM) system for forming a three-dimensional (3D) object, the system comprising an adhesive dispensing device for applying adhesive to object media layers of an object, each object media layer comprising a temporary region and a permanent region, wherein the adhesive dispensing device is configured to apply first and second adhesives to different regions of object media layers of the object.
11. The LOM system of claim 10 wherein the first adhesive is a temporary tack adhesive and the adhesive dispensing device is configured to apply the first adhesive to temporary regions of the object media layers
12. The LOM system of claims 10 or 11 wherein the second adhesive is a permanent bond adhesive and the adhesive dispensing device is configured to apply the second adhesive to permanent regions of the plurality of object media layers.
13. The LOM system of claims 11 or 12, wherein the first adhesive is applied for temporarily bonding temporary regions of object media layer during bonding and profiling.
14. The LOM system of claims 10 to 13, wherein the first adhesive is configured to melt and flow out of an interface between the temporary regions of the object media layers when the plurality of object media layers to which adhesive has been applied are heated above a predetermined temperature.
15. An adhesive comprising a tack adhesive for providing temporary bonding of layers to which the adhesive is applied.
16. The adhesive of claim 15 or the LOM system of claims 10 to 14 wherein the tack adhesive comprises a single solid wax.

17. The adhesive of claims 15 or 16 or the LOM system of claims 10 to 14, wherein the wax comprises beeswax.

18. The adhesive of claim 15 to 17 or the LOM system of claims 10 to 14, 5 wherein the tack adhesive comprises a microemulsion of wax particles in deionised water.

19. The adhesive of claim 15 to 18 or the LOM system of claims 10 to 14, wherein the wax comprises paraffin wax, beeswax or Carnauba wax.

10 20. The adhesive of claim 15 to 19 or the LOM system of claims 10 to 14, wherein the tack adhesive further comprises stearic acid.

15 21. The adhesive of claim 15 to 20 or the LOM system of claims 10 to 14, wherein the tack adhesive has a pH of between 10 and 11.

22. The adhesive of claim 15 to 21 or the LOM system of claims 10 to 14, wherein the tack adhesive is a temporary adhesive configured to be releasable and/or de-activateable and/or removable.

20 23. The LOM system of any of claims 10 to 22, wherein the second adhesive comprises a bond adhesive for permanently bonding the permanent regions of the object media layers to one another.

25 24. The LOM system of claim 23, wherein the bond adhesive comprises a microemulsion of ethylene vinyl acetate (EVA) co-polymer glue emulsion particles in deionised water.

30 25. The LOM system of claim 23 or 24, wherein the bond adhesive comprises approximately 5% EVA solids in deionised water.

26. The LOM system of any of claims 23 to 25, wherein the bond adhesive has a viscosity of about 1.66 mPas.
27. The LOM system of any of claims 23 to 26, wherein the bond adhesive has 5 a surface tension of about 53.65 nM/m.
28. The LOM system of any of claims 10 to 14 and 23 to 27, wherein each of the first and second adhesives has a viscosity of less than 50 cP.
- 10 29. The LOM system of any of claims 10 to 14 and 23 to 28, wherein each of the first and second adhesives has a viscosity in the range of 1 to 10 cP.
30. The LOM system of any of claims 10 to 14 and 23 to 29, wherein each of the first and second adhesives has a surface tension greater than 34 dyne/cm.
- 15
31. The LOM system of any of claims 10 to 14 and 23 to 30, wherein the first and second adhesives are configured to be inkjet printed.
32. A bonding module for bonding a plurality of individual object media layers to 20 form a three-dimensional (3D) object in in a Layered Object Manufacturing (LOM) system, each object media layer comprising temporary regions to which a first tack adhesive is applied and permanent regions to which a second bond adhesive is applied, wherein the bonding module comprises a heating element for heating the plurality of adhesive applied object media 25 layers.
33. The bonding module of claim 31, wherein the heating element is configured to heat the plurality of adhesive applied object media layers above a predetermined temperature, causing the first adhesive to melt and flow out 30 of an interface between the temporary regions, and causing the second bond adhesive to permanently bond together the bond regions.

34. The bonding module of claim 31 or 32, wherein the bonding module comprises a build table for stacking the plurality of object media layers thereon, the build table being configured to be movable to bring the object media layers into contact with the heating element.

5

35. The bonding module of any of claims 31 to 33, wherein the heating element comprises a hotplate.

36. The bonding module of any of claims 32 to 34, wherein the predetermined

10 temperature is at least 80 ° C.

37. The bonding module of any of claims 31 to 35, comprising the adhesive dispensing device of any of claims 1 to 9.

15 38. A Layered Object Manufacturing (LOM) system configured to assemble a plurality of individual printed media layers to form a three-dimensional (3D) object, the system comprising:

a collator configured to assemble the plurality of the individual printed media layers to form the 3D object,

20 the collator comprising the adhesive dispensing device of any of claims 1 to 9 and the bonding module of any of claims 31 to 37.

39. The system of claim 38, comprising a ink printing module for printing each of a plurality of object media layers prior to collation.

25

40. The system of claim 38 or 39, wherein the collator comprises a profiling module configured to effect a profiling of individual ones of the plurality of media layers to effect a desired 3D shape within the 3D object.

30 41. A method of bonding a plurality of individual object media layers to form a three-dimensional (3D) object in in a Layered Object Manufacturing (LOM)

system, each object media layer comprising temporary regions and permanent regions comprising:

5 applying a first tack adhesive to the temporary regions of each of a plurality of object media layers;

10 5 applying a second bond adhesive to the permanent regions of each of the plurality of object media layers;

15 positioning the object media layers on top of each other to form the object;

10 10 heating the object media layers above a predetermined temperature causing the first adhesive to melt and flow out of an interface between the temporary regions

separating the temporary regions from the LOM object.

42. The method of claim 41, wherein heating the object media layers above a

15 predetermined temperature causes the second bond adhesive to bond the permanent regions permanently to form a completed LOM object.

43. The method of claims 41 or 42 comprising heating the object media layers to a temperature above the melting point of a wax used in the first adhesive.

20

44. The method of claim 41 to 43, comprising heating the object media layers to a temperature above 80 °C.

45. The method of claims 41 to 44 heating of the first adhesive causes capillary flow of the first adhesive and causing a debonding of the temporary regions of the object media layers.

46. The method of claims 41 to 45 wherein the first adhesive is a temporary adhesive and the object media layers comprise sheets of paper and heating causes the capillary flow of the first temporary adhesive causing a debonding of the paper sheets.

30



Application No: GB1303468.1
Claims searched: 1-14, 16-46

Examiner: Mr Philip Osman
Date of search: 18 October 2013

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	-	US2004/045661 A1 (BAR-EREZ et al) See abstract and figures
A	-	GB2323553 A (BIRD) See abstract and figures
A	-	US6146487 A (LEE et al) See abstract and figures

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^X :

Worldwide search of patent documents classified in the following areas of the IPC

B29C; B32B

The following online and other databases have been used in the preparation of this search report

EPODOC, WPI

International Classification:

Subclass	Subgroup	Valid From
B29C	0067/00	01/01/2006

用于分层对象制造的粘性和结合粘合剂系统和方法

一种在形成 3 维(3D)对象的分层对象制造(LOM)系统中使用的粘合剂分配装置，其配置为将粘合剂施加到包括临时区域 105 和永久区域 11 的对象介质层。第一粘合剂 1 被施加到临时区域 105，且第二粘合剂 2 施加到永久区域 110。在完成分层对象后，第一粘合剂可以被去结合，例如通过施加热，由此便于去除临时材料。还被提供有第一和第二粘合剂剂型(formulations)、用于使用第一和第二粘合剂以结合多个单一对象介质层的结合模块和包括该结合模块的 LOM 系统。