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(54) Title: METHOD OF PRINTING AN OPTICAL ELEMENT

(57) Abstract: The present inventions refers to a method for printing an optical element (11) comprising the steps of ejecting at least one droplet (6) of printing material comprising silicone towards a substrate (8) in a first step and curing the droplet deposited on the substrate in a second step.

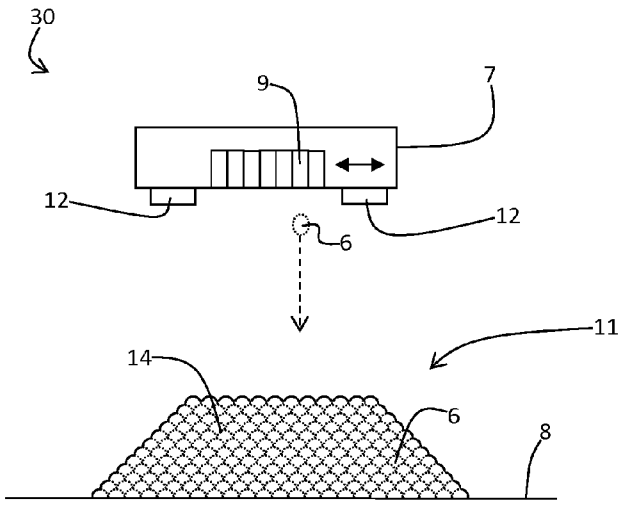

Fig. 1

WO 2014/108364 A1

DESCRIPTION

TITLE

Method of printing an optical element

BACKGROUND

The present inventions refers to a method for printing an optical element comprising the steps of ejecting at least one droplet of printing material towards a substrate in a first step and curing the droplet deposited on the substrate in a second step.

It is well known from the applicant's prior art document WO 2010 / 091 888 A1 to print three-dimensional structures, in particular optical elements, by means of droplet-on-demand inkjet technologies. A movable print head is used for depositing single droplets of a transparent printing ink a certain positions onto a substrate. The print head is provided with UV light sources for curing the deposited droplets by UV irradiation. A three-dimensional optical element is built up by a plurality of deposited and cured droplets arranged at least partially one above the other and one beside the other.

Usually, a polymer based printing ink is used as curable printing ink for printing the three dimensional structures. A disadvantage of this purpose is that the heat stability of the three dimensional structures is comparatively low, so that the three dimensional structures are not suitable as optics for those light sources which generate much heat energy. There is a danger that the optic is melted through the heat.

SUMMARY

It is an object of the present invention to provide a method for printing an optical element and to provide an optical element, wherein the optical element is suitable as optic for heat producing light sources.

The object of the present invention can be achieved with a method for printing an optical element comprising the steps of ejecting at least one droplet of printing material comprising silicone towards a substrate in a first step and curing the droplet deposited on the substrate in a second step.

It is herewith advantageously possible to built up an optical element which comprises a substantially higher heat stability compared to the printed optical elements known from the prior art because silicone has a comparatively high thermal resistance, in particular up to 250° Celsius. Simultaneously, silicone can be used as liquid printing ink in a conventional drop-on-demand inkjet printer. Silicone in the sense of the present invention is preferably a polymer that includes silicon together with carbon, hydrogen, oxygen, and sometimes other elements.

According to a preferred embodiment of the present invention, the printing material ejected in the first step comprises a mixture of silicone and acrylics. Additionally or alternatively, the printing material ejected in the first step comprises a viscosity between 5 and 12 centipoise and/or the printing material ejected in the first step comprises an epoxy modified cationic UV curing silicone.

According to another preferred embodiment of the present invention, the deposited droplet is cured in the second step by ultraviolet irradiation, wherein preferably the amount of ultraviolet irradiation is altered during the second step.

According to another preferred embodiment of the present invention, the deposited droplet is cured in the second step by infrared irradiation. The infrared irradiation is performed e.g. by an infrared light source incorporated into the print head, for instance.

According to another preferred embodiment of the present invention, the printing material of the at least one droplet is heated at least to 75 degree Celsius, preferably at least to 100 degree Celsius and particularly preferably at least to 150 degree Celsius before and/or while ejecting the droplet during the first step. It is herewith advantageously possible to achieve a certain viscosity of the printing ink during ejection of the droplets towards the substrate.

Preferably, a plurality of droplets are ejected towards the substrate in the first step and cured in the second step. In this manner, an arbitrary optical element of almost any form and shape can be printed flexible and individually customized.

According to another preferred embodiment of the present invention, the further droplets of printing material are ejected towards the substrate in a third step and cured in a fourth step, wherein the droplets and the further droplets are cured again in a fifth step. The fifth steps can be used as a final curing step to obtain a hardened outer surface of the optical element. Preferably, the droplets and the further droplets are finally cured in the fifth step by providing heat to the droplets, in particular using infrared irradiation.

In principle, it is conceivable that the substrate is heated in the second, fourth and/or fifth step.

Another subject of the present invention is a printer for printing an optical element by performing the above mentioned method according to the present invention, wherein the printer comprises a reservoir containing a printing material comprising silicone, a print head having ejection means for ejecting the at least one droplet towards the substrate and a curing means for curing the at least one deposited droplet. Preferably, the curing means comprises a UV spot, a IR spot and/or a heat source coupled to the substrate. Particularly, the printer comprises a heater for heating the printing material in the reservoir at least to 75 degree Celsius, preferably at least to 100 degree Celsius and particularly preferably at least to 150 degree Celsius.

Another subject of the present invention is an optical element printed by the method above mentioned method according to the present invention, wherein the optical elements is built up by multiple droplets of printing ink, wherein the printing ink comprises a silicone.

Preferably, the printing ink comprises a mixture of silicone and acrylics. Additionally or alternatively, the printing material comprises a viscosity between 5 and 12 centipoise before curing and/or the printing material comprises an epoxy modified cationic UV curing silicone. Silicone in the sense of the present invention is preferably a polymer that includes silicon together with carbon, hydrogen, oxygen, and sometimes other elements.

These and other characteristics, features and advantages of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawing, which illustrates, by way of example, the principles of the invention. The description is given for the sake of example only, without limiting the scope of the invention. The reference figures quoted below refer to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 illustrates schematically a method for printing a three-dimensional structure and a printed article according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION

The present invention will be described with respect to particular embodiments and with reference to certain drawings but the invention is not limited thereto but only by the claims. The drawings describe the invention only schematically and non-limiting. In the drawings, the size of some of the elements may be exaggerated and not drawn on scale for illustrative purposes.

Where an indefinite or definite article is used when referring to a singular noun, e.g. “a”, “an”, “the”, this includes a plural of that noun unless something else is specifically stated.

Furthermore, the terms first, second, third and the like in the description and in the claims are used for distinguishing between similar elements and not necessarily for describing a sequential or chronological order. It is to be understood that the terms so used are interchangeable under appropriate circumstances and that the embodiments of the invention described herein are capable of operation in other sequences than described of illustrated herein.

In figure 1 a method for printing an optical element 11 and a printed optical element 11 respectively according to the exemplary embodiment of the present invention is schematically shown. It could be seen from figure 1 that a plurality of droplets 6 of printing ink are deposited onto a substrate 8 by means of a print head 7 in order to build up a three-dimensional optical element 11. The droplets 6 are deposited side by side and one above the other, as indicated by the dashed lines 14, in order to generate the three-dimensional form. The printing ink comprises an UV curable silicone; preferably an epoxy modified cationic UV curing silicone. The print head 7 moves over the substrate 8 and ejects the droplets 6 of printing ink by means of ejecting nozzles 9 to deposit the individual droplets 6 in a certain pattern. It is conceivable that the printing ink is heated inside the print head 7 before ejection in order to increase the viscosity of the silicone. After deposition of the droplets 6, adjacent deposited droplets 6 preferably merge which each other (the lower droplets 6 are therefore illustrated only schematically by the dashed lines 14) and are subsequently cured by UV-light emitted by LED’s (light emitting diodes) 12 of the print head 7. Alternatively, the deposited printing material is cured by irradiation of infrared light. In this case, the print head 7 is provided with IR emitting light sources. Advantageously, the silicone based printing ink is UV resistant, clear and can stand up to extreme temperatures, so that the optical element 11 can be used as an optic for a light source which generates much heat energy without the danger of melting or getting unclear. Preferably, the printing ink is a mixture of silicone and acrylics with a viscosity between 5 and 12 centipoise during ejection. The print head 7 is a part of a drop-on-demand inkjet printer 30.

PATENT CLAIMS

1. Method for printing an optical element (11) comprising the steps of:

   - Ejecting at least one droplet (6) of printing material comprising silicone towards a substrate (8) in a first step and;

   - Curing the droplet (9) deposited directly or indirectly onto the substrate (8) in a second step.

2. Method according to claim 1, wherein the printing material ejected in the first step comprises a mixture of silicone and acrylics.

3. Method according to claim 2, wherein the printing material ejected in the first step comprises a viscosity between 5 and 12 centipoise.

4. Method according to one of the preceding claims, wherein the printing material ejected in the first step comprises an epoxy modified cationic UV curing silicone.

5. Method according to one of the preceding claims, wherein the deposited droplet (6) is cured in the second step by ultraviolet irradiation.

6. Method according to claim 5, wherein the amount of ultraviolet irradiation is altered during the second step.

7. Method according to one of the preceding claims, wherein the deposited droplet (6) is cured in the second step by infrared irradiation.

8. Method according to one of the preceding claims, wherein the printing material of the at least one droplet (6) is heated at least to 75 degree Celsius, preferably at least to 100 degree Celsius and particularly preferably at least to 150 degree Celsius before and/or while ejecting the droplet (6) during the first step.

9. Method according to one of the preceding claims, wherein a plurality of droplets (6) are ejected towards the substrate (8) in the first step and cured in the second step.

10. Method according to one of the preceding claims, wherein further droplets (6) of printing material are ejected towards the substrate (8) in a third step and cured in a fourth step, wherein the droplets (6) and the further droplets (6) are cured again in a fifth step.

11. Method according to claim 10, wherein the droplets (6) and the further droplets (6) are finally cured in the fifth step by providing heat to the droplets (6) and further droplets (6), in particular by using infrared irradiation.

12. Method according to one of the preceding claims, wherein the substrate (8) is heated in the second, fourth and/or fifth step.

13. Printer (30) for printing an optical element (11) by performing a method according to one of the preceding claims, wherein the printer (30) comprises a reservoir containing a printing material comprising silicone, a print head (7) having ejection means (9) for ejecting the at least one droplet (6) towards the substrate (8) and a curing means (12) for curing the at least one deposited droplet (6).

14. Printer (30) according to claim 13, wherein the curing means (12) comprises a UV spot, a IR spot and/or a heat source coupled to the substrate (8).

15. Printer (30) according to one of the claims 13 or 14, wherein the printer (30) comprises a heater for heating the printing material in the reservoir at least to 75 degree Celsius, preferably at least to 100 degree Celsius and particularly preferably at least to 150 degree Celsius.

16. Optical element (11) printed by a method according to one of the claims 1 to 12, wherein the optical element (11) is built up by multiple droplets (6) of printing ink, wherein the printing ink (6) comprises a silicone.

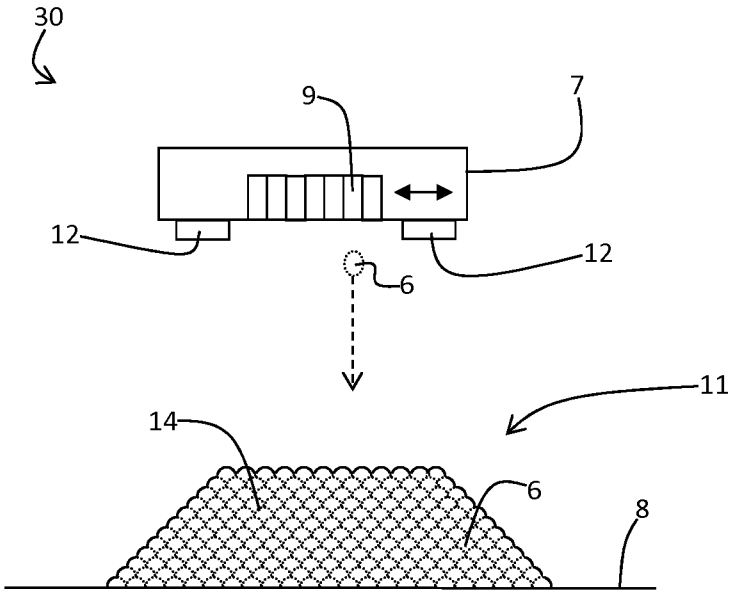

Fig. 1

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. B29D11/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B29D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 2006/012058 A1 (HASEI HIRONORI [JP]) 19 January 2006 (2006-01-19) paragraphs [0025], [0027], [0029], [0030] -----	1-5,9, 13-16 6
X	US 2009/147367 A1 (BLONDAL DANIEL J [CA] ET AL) 11 June 2009 (2009-06-11) paragraph [0057] -----	1,8, 13-16
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X	US 2005/058773 A1 (HASEI HIRONORI [JP] ET AL) 17 March 2005 (2005-03-17) paragraph [0102]; claims 1-4 -----	1,8-12

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2014/050079

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	EP 2 474 404 A1 (LUXEXCEL HOLDING BV [NL]) 11 July 2012 (2012-07-11) paragraphs [0015], [0032] -----	13,14 6

INTERNATIONAL SEARCH REPORT

Information on patent family members

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