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(54) METHOD OF FABRICATING MICROELECTROMECHANICAL SYSTEMS DEVICES

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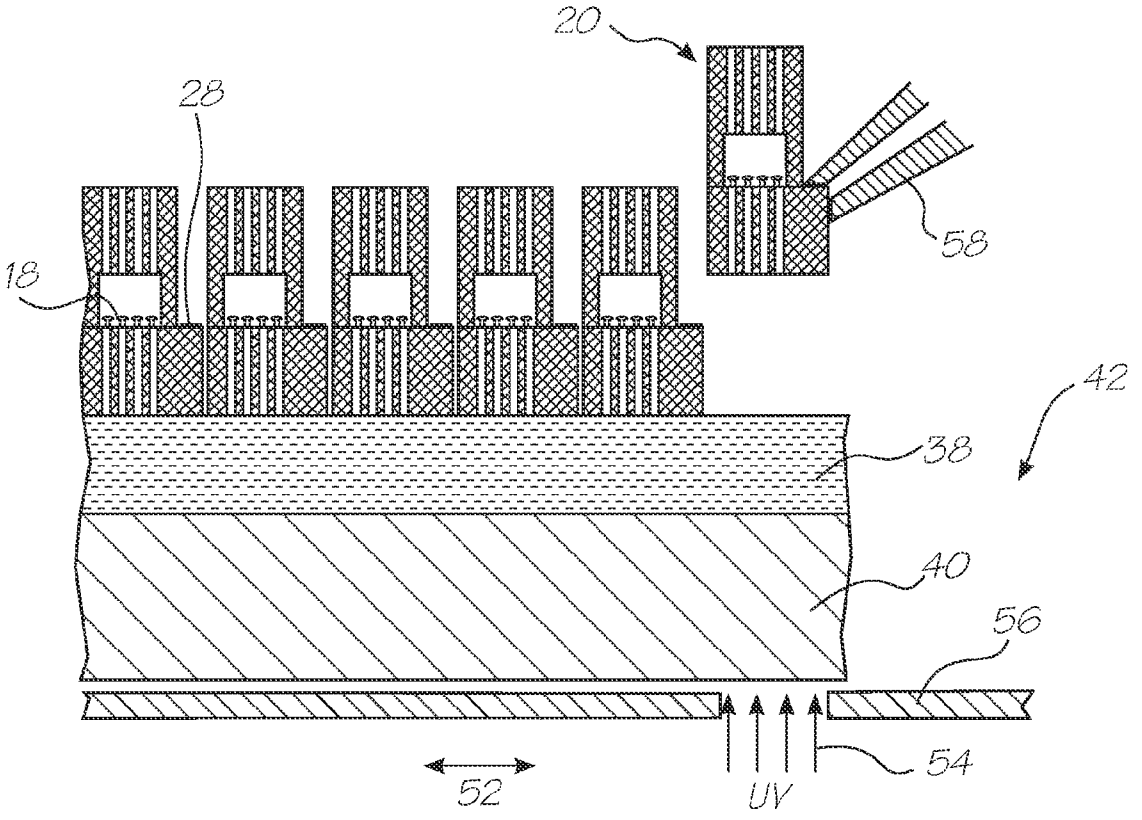
(57) **ABSTRACT**

A method of fabricating microelectromechanical systems devices is disclosed. A silicon substrate having a plurality of microelectromechanical systems elements formed on a first surface thereof is provided. A guard layer defining a plurality of recesses is applied to the silicon substrate such that respective microelectromechanical systems elements are located within respective recesses. The silicon substrate is then segmented into discrete parts and an adhesive layer is bonded to a second surface of the silicon substrate. The guard layer is next segmented into discrete parts corresponding to the discrete parts of the silicon substrate, thereby forming individual microelectromechanical systems devices. Finally, the adhesive layer is selectively exposed to a light source allowing removal of individual microelectromechanical systems devices.



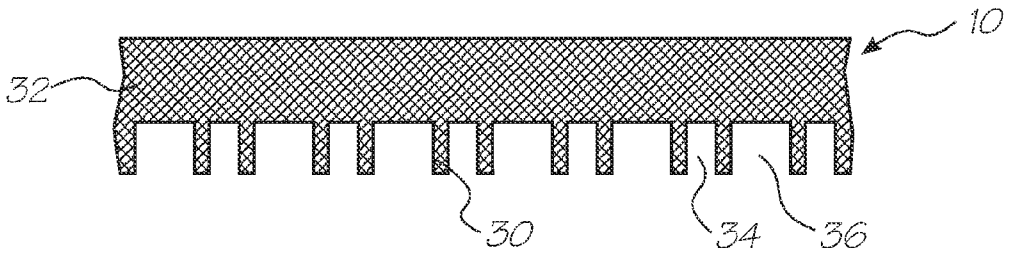


FIG. 1

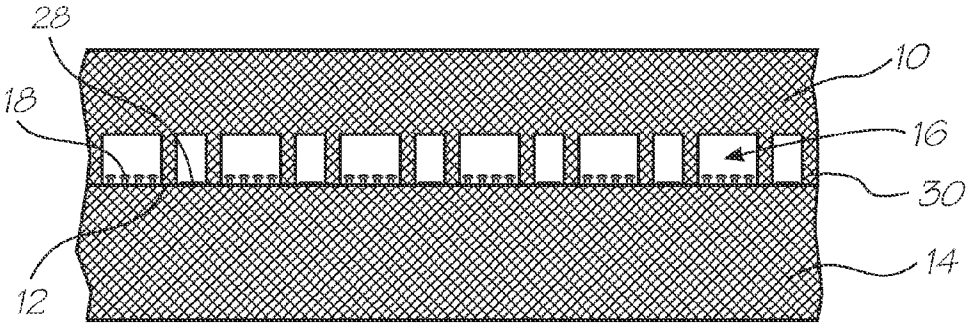


FIG. 2

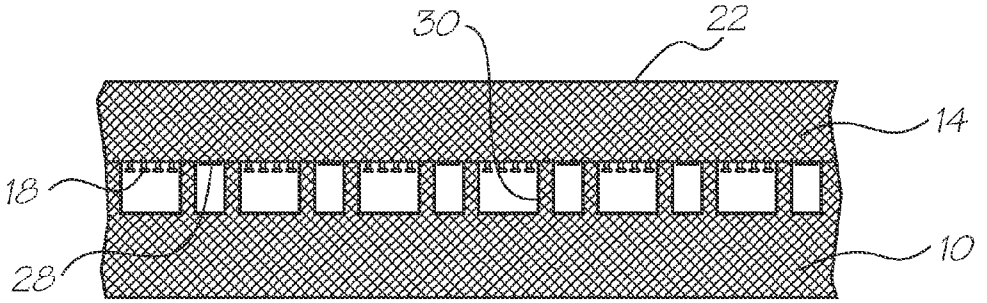


FIG. 3

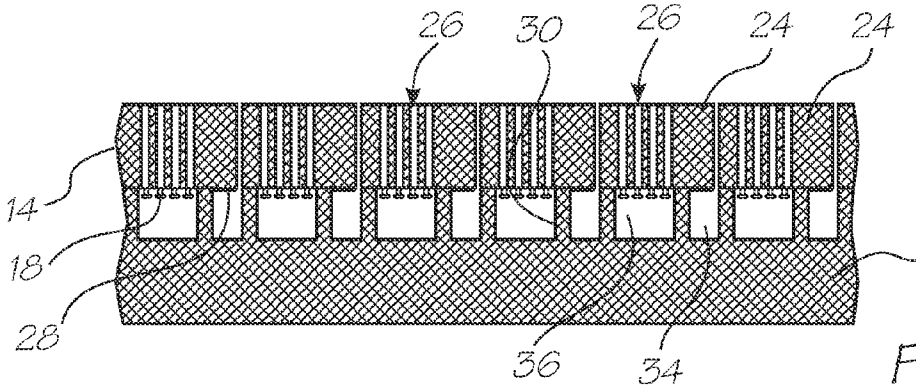


FIG. 4

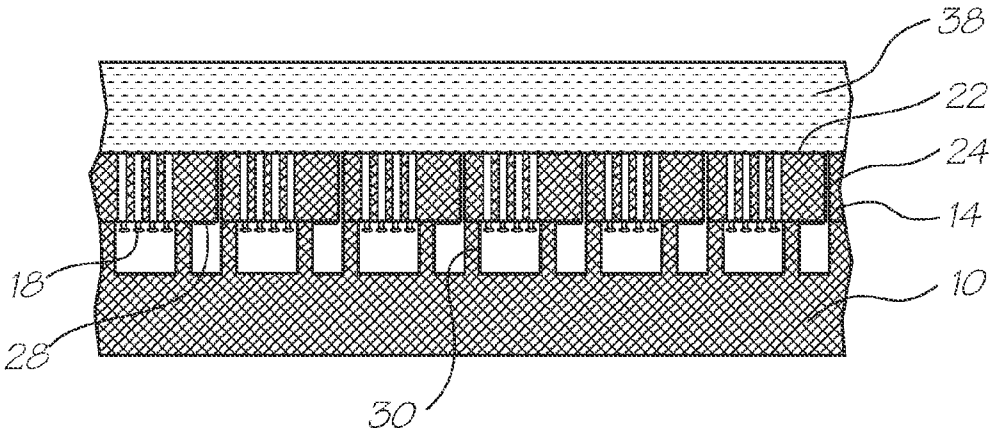


FIG. 5

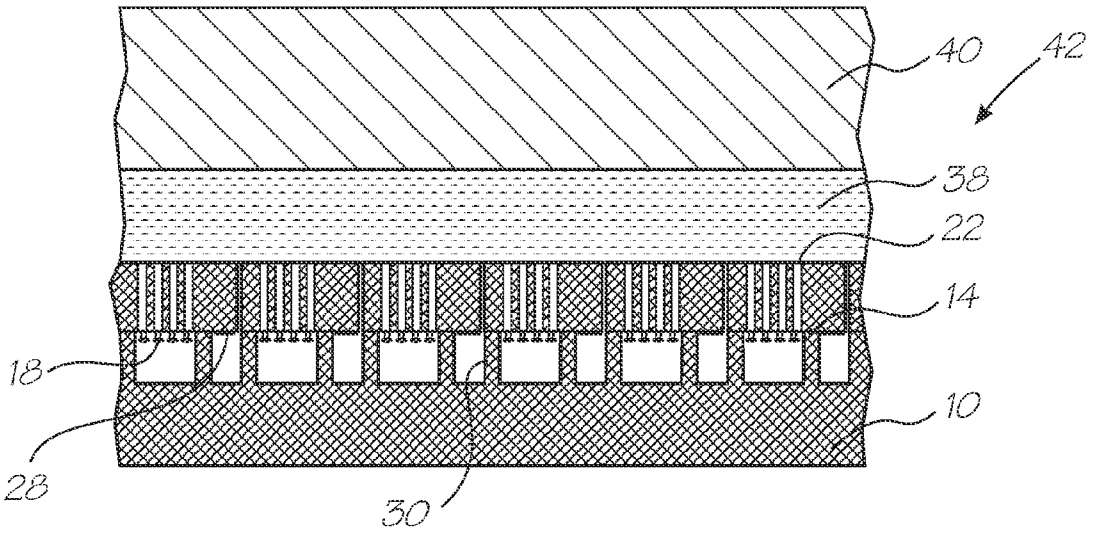


FIG. 6

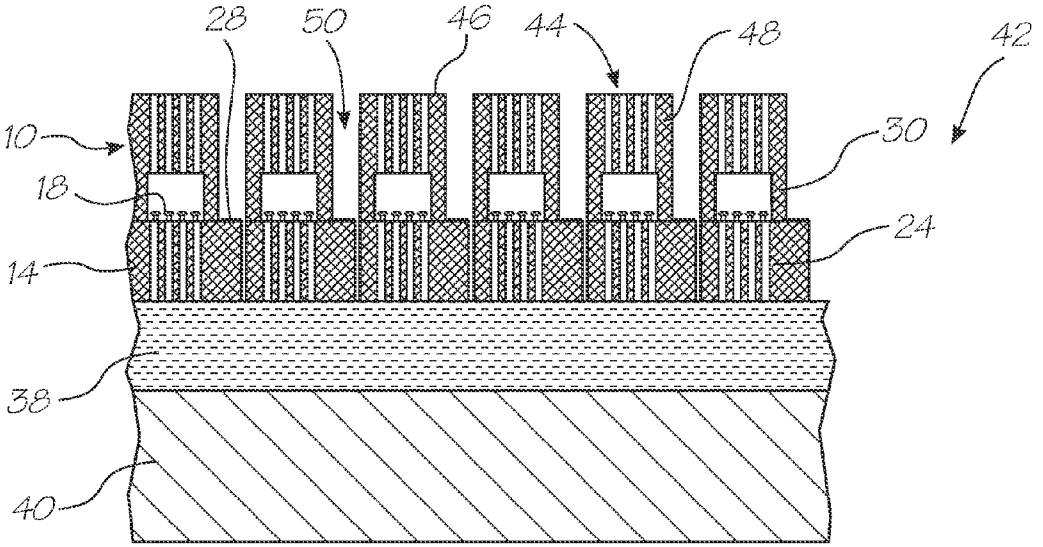


FIG. 7

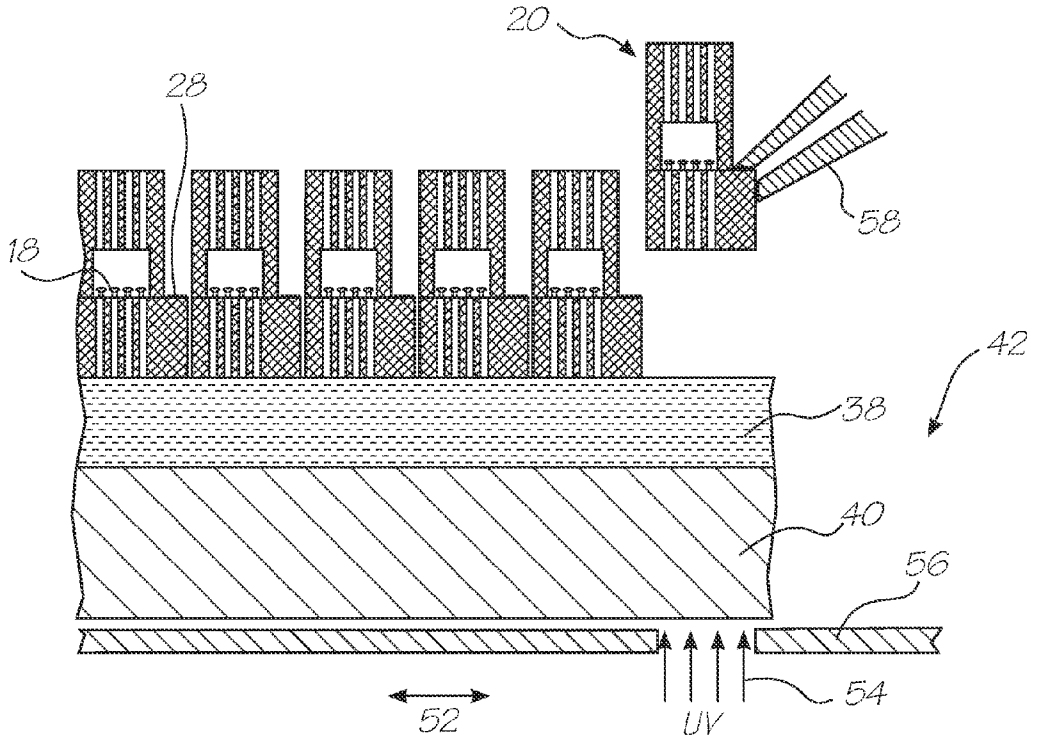


FIG. 8

METHOD OF FABRICATING MICROELECTROMECHANICAL SYSTEMS DEVICES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This Application a continuation application of U.S. application Ser. No. 12/268,966 filed on Nov. 11, 2008, which is a continuation application of U.S. application Ser. No. 11/450,431 filed on Jun. 12, 2006, now issued U.S. Pat. No. 7,465,405, which is a continuation application of U.S. application Ser. No. 10/296,660 filed on Aug. 1, 2003, now issued U.S. Pat. No. 7,063,993, which is a national phase (371) application of PCT/AU00/00583, filed on May 24, 2000, all of which are herein incorporated by reference.

FIELD OF THE INVENTION

[0002] This invention relates to the fabrication of devices incorporating microelectromechanical systems (MEMS). More particularly, the invention relates to a method of fabricating a MEMS device using at least one UV curable tape. For the sake of brevity, such a device shall be referred to below as a MEMS device and the part of the device comprising the microelectromechanical system shall be referred to as a MEMS layer.

SUMMARY OF THE INVENTION

[0003] According to an aspect of the present invention there is provided a method of fabricating microelectromechanical systems devices, the method comprising the steps of:

[0004] forming a plurality of microelectromechanical systems elements on a first surface of a silicon substrate;

[0005] applying a guard layer to the first surface of the silicon substrate, the guard layer defining a plurality of recesses and respective microelectromechanical systems elements are received within respective recesses;

[0006] segmenting the silicon substrate into discrete parts, each discrete part including at least one microelectromechanical systems element;

[0007] bonding an adhesive layer to a second surface of the silicon substrate, the second surface being opposite said first surface;

[0008] segmenting the guard layer corresponding to the discrete parts of the silicon substrate thereby forming individual microelectromechanical systems devices; and

[0009] selectively exposing the adhesive layer to a light source allowing removal of individual microelectromechanical systems devices.

[0010] Various other aspects of the present invention are also disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The invention is now described by way of example with reference to the accompanying diagrammatic drawings in which:

[0012] FIGS. **1** to **8** show various stages in a method of fabricating MEMS devices, in accordance with the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0013] In an initial step, illustrated at **10** in FIG. **1** of the drawings, of a method of fabricating a MEMS device, in accordance with the invention, a layer **10** is provided to be applied to a first surface **12** of a silicon substrate or wafer **14**. The wafer **14** carries a surface macromachined MEMS layer **16** on the first surface **12** of the wafer **14**. The MEMS layer **16** comprises individual MEMS elements **18**.

[0014] The invention has particular application in the manufacture of ink jet printheads. For ease of explanation, the invention will be described with reference to that application. Thus, the layer **10** is a nozzle guard layer or wafer which is applied to the surface **12** of the silicon substrate **14**. Each individual MEMS element **18** is in the form of a nozzle assembly. Each nozzle assembly **18** comprises an ink ejection nozzle and its associated actuator. The actuator acts on the nozzle for effecting ink ejection, on demand.

[0015] The purpose of the method of manufacture is to form individual MEMS chips **20** (FIG. **8**).

[0016] Hence, after the nozzle guard layer **10** has been applied to the wafer **14**, the wafer **14** is turned over to expose a reverse side **22** as shown in FIG. **3** of the drawings.

[0017] Various operations are then carried out on the wafer **14**. In particular, the wafer **14** is back etched, from the surface **22** towards the surface **12** to separate the silicon wafer into discrete parts **24**. In addition, in this application of the invention, ink inlet apertures **26** are etched through the parts **24**. It is to be noted that each part **24** comprises a plurality of MEMS elements **18** and a bond pad **28**. Also, as shown more clearly in FIG. **1** of the drawings, the layer **10** has a plurality of struts **30** which support a body **32** of the layer **10** in spaced relationship above the surface **12** of the wafer **14** such that the MEMS elements **18** and the bond pads **28** are protected by the body **32**. The struts **30** define chambers **34** and **36**. The chambers **34** overlie the bond pads **28** while the chambers **36** overlie the array of MEMS elements **18** of each part **24**.

[0018] A holding means in the form of an adhesive tape **38** is bonded to the surface **22** of the layer **14** as illustrated in FIG. **5** of the drawings. The tape **38** is bonded to the layer **14** by means of a curable adhesive. The adhesive is curable in the sense that it loses its adhesive properties or "tackiness" when exposed to ultraviolet (UV) light.

[0019] Depending on the equipment used, a handling means in the form of a glass, quartz, alumina or other transparent handle wafer **40** is secured to an opposite surface of the tape **38**.

[0020] The wafer **40**, the tape **38**, the silicon wafer **14** and the nozzle guard layer **10** define a laminate **42**. The laminate **42** is then turned over, as shown in FIG. **7** of the drawings.

[0021] Predetermined operations are carried out on the layer **10**. More particularly, passages **44** are etched through the layer **10** from an outer surface **46** towards the chambers **36**. In addition, individual nozzle guards **48** are formed by etching to remove material as shown at **50** in FIG. **7** of the drawings. The removal of this material exposes the bond pads **28** of each chip **20**. Upon completion of this operation, the individual chips **20** are formed.

[0022] In this embodiment of the invention, each chip **20** has a plurality of MEMS elements **18** in an array formed thereon.

[0023] The laminate **42** is placed on an xy wafer stage (not shown) which is reciprocated, as illustrated by arrow **52** in FIG. **8** of the drawings. Each MEMS chip **20**, when it is desired to remove it, is exposed to UV light as indicated by arrows **54** through a mask **56**. This cures the adhesive of the tape **40** locally in a region beneath one particular MEMS chip **20** at a time to enable that MEMS chip **20** to be removed from

the tape **38**. The MEMS chip **20** is removed from the tape **38** by means of a transporting means including a vacuum pickup **58**.

[0024] Hence, it is an advantage of the invention, that a method of fabrication is provided which facilitates the performing of various operations to fabricate the individual MEMS chip **20** and which facilitates removal of the MEMS chips **20** for packaging. It will be appreciated that devices of the kind in question are measured in micron dimensions. Accordingly, the MEMS elements **18** on such devices are extremely fragile. The provision of the nozzle guard layer **10** and the use of the UV curable tape **38** facilitates that the MEMS elements **18** are not touched by solids or liquids after they are released by the release etch.

[0025] It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

1. A method of fabricating microelectromechanical systems devices, the method comprising the steps of:

forming a plurality of microelectromechanical systems elements on a first surface of a silicon substrate;

applying a guard layer to the first surface of the silicon substrate, the guard layer defining a plurality of recesses and respective microelectromechanical systems elements are received within respective recesses;

segmenting the silicon substrate into discrete parts, each discrete part including at least one microelectromechanical systems element;

bonding an adhesive layer to a second surface of the silicon substrate, the second surface being opposite said first surface;

segmenting the guard layer corresponding to the discrete parts of the silicon substrate thereby forming individual microelectromechanical systems devices; and

selectively exposing the adhesive layer to a light source allowing removal of individual microelectromechanical systems devices.

2. A method as claimed in claim **1**, wherein said light source is an ultraviolet light source.

3. A method as claimed in claim **1**, wherein said light source exposes said adhesive layer through a mask.

4. A method as claimed in claim **1**, further comprising the step of applying a handling layer to the adhesive layer so that the adhesive layer is located between the handling layer and the substrate, said handling layer being at least partially transparent.

5. A method as claimed in claim **1**, wherein said microelectromechanical systems devices are printheads and said microelectromechanical systems elements are ink ejection nozzles, said method comprising the further step of etching a plurality of ink supply channels in the second surface of the silicon substrate prior to bonding the adhesive layer to the second surface.

6. A method as claimed in claim **5**, comprising the further step of etching a plurality of ink ejection channels in the guard layer so that each ink ejection channel is in register with respective ink ejection nozzles.

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