

CLAIMS:

1. A method of preparing a substrate for substrate bonding comprising:
forming a recess in a substrate surface of the substrate;
5 forming a bondable dielectric layer on the substrate surface of the substrate having a bonding surface on an opposite side of the bondable dielectric layer to the substrate surface, the recess and the bondable dielectric layer defining a dielectric cavity having a dielectric cavity volume;
forming a plug configured to make electrical contact to the substrate in the
10 dielectric cavity volume, the plug having a plug volume which is less than the dielectric cavity volume, wherein the plug extends from the dielectric cavity beyond the bonding surface in a direction generally normal to the bonding surface; and
coining the plug by compressing the substrate between opposing planar surfaces such that a contact surface of the plug is made co-planar with the bonding
15 surface.
2. A method of preparing a substrate according to claim 1, wherein,
the plug extends from the dielectric cavity beyond the bonding surface by no more
than 5 μm .
20
3. A method of preparing a substrate for bonding according to claim 1 or claim 2,
wherein
following coining the plug has a cross sectional area co-planar with the bonding
surface of less than 10 μm x 10 μm .
25
4. A method of preparing a substrate for bonding according to any preceding claim,
the volume of the dielectric cavity volume is at least 10 % greater than the plug volume of
the plug.
- 30 5. A method of preparing a substrate for bonding according to any preceding claim,
further comprising:
subjecting the bonding surface to an activation treatment, wherein optionally the
bonding surface is exposed to a solution comprising OH^- ions following the activation
treatment.

6. A method of preparing a substrate for substrate bonding according to any preceding claim, wherein the plug comprises a noble metal.
7. A method of preparing a substrate for substrate bonding according to any preceding claim, wherein
5 the bondable dielectric layer comprises a silicon compound, wherein optionally, the bondable dielectric layer comprises at least one of: Silicon Dioxide, Silicon Nitride, Silicon Oxynitride, or Silicon Carbon nitride.
8. A method of preparing a substrate for substrate bonding according to any preceding claim, wherein a plurality of recesses are formed on the substrate surface, and each recess has a plug formed within.
9. A method of preparing a substrate for substrate bonding according to claim 8,
15 wherein the substrate comprises:
an array of Group III-nitride LEDs, the plurality of plugs configured to make electrical contact to the array of LEDs; or
CMOS electronics devices, the plurality of plugs configured to make electrical contact to the CMOS electronics devices.
10. A method of bonding a first substrate to a second substrate comprising:
i) preparing the first substrate for bonding comprising:
forming a first recess in a first substrate surface of the first substrate;
forming a first bondable dielectric layer on the first substrate surface of the
25 first substrate having a first bonding surface on an opposite side of the first bondable dielectric layer to the first substrate surface, the first recess and the first bondable dielectric layer defining a first dielectric cavity having a first dielectric cavity volume;
forming a first plug configured to make electrical contact to the first substrate
30 in the first dielectric cavity volume, the first plug having a first plug volume which is less than the first dielectric cavity volume, wherein the first plug extends from the first dielectric cavity beyond the first bonding surface in a direction generally normal to the first bonding surface; and
coining the first plug by compressing the first substrate between opposing
35 planar surfaces;

- ii) providing the second substrate for bonding, the second substrate comprising:
a second bondable dielectric layer and a second contact layer, provided on
a second surface of the second substrate, the second contact layer having a second
contact surface which is co-planar with a second dielectric surface of the second bondable
5 dielectric layer to form a second bonding surface;
iii) aligning the first bonding surface of the first substrate opposite the second bonding
surface of the second substrate such that the first plug is aligned with the second contact
layer; and
iv) bringing the first bonding surface of the first substrate into contact with the second
10 bonding surface of the second substrate and forming a bond between the first plug and the
second contact layer under compressive force.
11. A method of bonding a first substrate to a second substrate according to claim 10,
wherein
15 the first bonding surface and/or the second bonding surface is subjected to an
activation treatment, wherein optionally the first and/or second bonding surface is exposed
to a solution comprising OH⁻ ions following the activation treatment.
12. A method of bonding a first substrate to a second substrate according to claim 100
20 or claim 11, wherein
a cross-sectional area of the first plug in the plane of the first bonding surface is
less than a surface area of the second contact surface.
13. A method of bonding a first substrate to a second substrate according to any of
25 claims 10 to 12, wherein providing the second substrate for bonding comprises:
forming a second recess in the second substrate surface of the second
substrate
forming the second bondable dielectric layer on the second substrate
surface of the second substrate having the second bonding surface on an opposite
30 side of the second bondable dielectric layer to the second substrate surface, the
second recess and the second bondable dielectric layer defining a second dielectric
cavity having a second dielectric cavity volume;
forming a second plug configured to make electrical contact to the second
substrate in the second dielectric cavity volume, the second plug having a second
35 plug volume which is less than the second dielectric cavity volume, wherein the

second plug extends from the second dielectric cavity beyond the second bonding surface in a direction generally normal to the second bonding surface; and
coining the second plug by compressing the second substrate between opposing planar surfaces such that the second plug forms the second contact layer
5 having the second contact surface which is co-planar with the second bonding surface.

14. A method of bonding a first substrate to a second substrate according to any of claims 10 to 13, wherein
10 the first substrate and/or the second substrate is prepared for substrate bonding according to the method of any of claims 2 to 9.

15. A method of bonding a first substrate to a second substrate according to any of claims 10 to 12, wherein
15 the second contact layer is made co-planar with the second dielectric surface using a chemical mechanical polishing process.