CLAIMS

1. A chemical sensor ~~including~~comprising:

a first semiconductor substrate comprising a hole;

a second semiconductor substrate comprising a hole;

one or more metal layers between the first semiconductor substrate and the second semiconductor substrate such that the first semiconductor substrate, the second semiconductor substrate and the one or more metal layers form a cell including a cavity, the cavity having a depth of any value equal to or less than 100 μm;

an optical source; ~~and~~

an optical detector such that light emitted by the optical source passes through the cell to the optical detector;

a first non-metal layer on a first inner surface of the cavity; and

a second non-metal layer on a second inner surface of the cavity opposite the first inner surface;

wherein the first semiconductor substrate, the second semiconductor substrate and the one or more metal layers also define at least one inlet for fluid to flow into the cavity and at least one outlet for fluid to flow out of the cavity;

wherein the one or more metal layers extend from between the first semiconductor substrate and the second semiconductor substrate to sidewalls of the cavity, the cavity at least partially defined by the hole of the first semiconductor substrate and the hole of the second semiconductor substrate, thereby joining the first non-metal layer to the second non-metal layer; and

wherein the one or more metal layers comprises:

a first adhesion layer in contact with at least a portion of the first semiconductor substrate;

a first bonding layer comprising gold, the first bonding layer in contact with the first adhesion layer;

a second bonding layer comprising gold, the second bonding layer in contact with the first bonding layer; and

a second adhesion layer in contact with at least a portion of the second semiconductor substrate and the second bonding layer.

2. The chemical sensor according to claim 1, ~~further comprising:~~

wherein ~~the cavity has a~~the depth of the cavity is of any value less than 100 μm.

3. The chemical sensor according to claim 1,

wherein the first semiconductor substrate and the second semiconductor substrate comprise silicon or germanium.

~~4. The chemical sensor according to claim 1,~~

~~wherein the one or more metal layers comprises:~~

~~a first adhesion layer in contact with at least a portion of the first semiconductor substrate;~~

~~a first bonding layer in contact with the first adhesion layer;~~

~~a second bonding layer in contact with the first bonding layer; and~~

~~a second adhesion layer in contact with at least a portion of the second semiconductor substrate.~~

~~5.~~4.The chemical sensor according to claim 4~~1~~,

wherein the first adhesion layer and the second adhesion layer comprise chromium or titanium.

~~6. The chemical sensor according to claim 4,~~

~~wherein the first bonding layer and the second bonding layer comprise gold.~~

~~7.~~5.The chemical sensor according to claim 1,

wherein the first semiconductor substrate, the second semiconductor substrate and the one or more metal layers form a further cell including a further cavity.

~~8.~~6.The chemical sensor according to claim ~~7~~5,

wherein the further cavity is sealed.

~~9.~~7. The chemical sensor according to claim ~~7~~5,

wherein the first semiconductor substrate, the second semiconductor substrate and the one or more metal layers also define at least one further inlet for fluid to flow into the further cavity and at least one further outlet for fluid to flow out of the further cavity.

~~10.~~8. The chemical sensor according to claim ~~7~~5, further comprising:

a further optical detector such that light emitted by the optical source passes through the further cell to the further optical detector.

~~11.~~9. The chemical sensor according to claim 1,

wherein the optical source and the optical detector are unpackaged dies bonded to the cell using wafer to wafer bonding methods or chip to wafer bonding methods.

~~12.~~10. A method of forming a chemical sensor, the method further comprising:

forming one or more metal layers between a first semiconductor substrate, the first semiconductor substrate comprising a hole, and a second semiconductor substrate, the second semiconductor substrate comprising a hole, such that the first semiconductor substrate, the second semiconductor substrate and the one or more metal layers form a cell including a cavity, the cavity having a depth of any value equal to or less than 100 μm;

providing an optical source; ~~and~~

providing an optical detector such that light emitted by the optical source passes through the cell to the optical detector;

forming a first non-metal layer on a first inner surface of the cavity; and

forming a second non-metal layer on a second inner surface of the cavity opposite the first inner surface;

wherein the first semiconductor substrate, the second semiconductor substrate and the one or more metal layers also define at least one inlet for fluid to flow into the cavity and at least one outlet for fluid to flow out of the cavity;

wherein the one or more metal layers extend from between the first semiconductor substrate and the second semiconductor substrate to sidewalls of the cavity, the cavity at least partially defined by the hole of the first semiconductor substrate and the hole of the second semiconductor substrate, thereby joining the first non-metal layer to the second non-metal layer; and

wherein the one or more metal layers comprises:

a first adhesion layer in contact with at least a portion of the first semiconductor substrate;

a first bonding layer comprising gold, the first bonding layer in contact with the first adhesion layer;

a second bonding layer comprising gold, the second bonding layer in contact with the first bonding layer; and

a second adhesion layer in contact with at least a portion of the second semiconductor substrate and the second bonding layer.

~~13.~~11. The method according to claim ~~12~~10, ~~further comprising:~~

wherein ~~the cavity has a~~the depth of the cavity is of any value less than 100 μm.

~~14.~~12. The method according to claim ~~12~~10,

wherein the first semiconductor substrate and the second semiconductor substrate comprise silicon or germanium.

~~15.~~13. The method according to claim ~~12~~10,

wherein the first semiconductor substrate is patterned before forming ~~a~~the first adhesion layer of the one or more metal layers in contact with the first semiconductor substrate, and forming ~~a~~the first bonding layer of the one or more metal layers in contact with the first adhesion layer;

wherein the second semiconductor substrate is patterned before forming ~~a~~the second adhesion layer of the one or more metal layers in contact with the ~~first~~second semiconductor substrate, and forming ~~a~~the second bonding layer of the one or more metal layers in contact with the second adhesion layer; and

wherein the method further comprises bonding the first bonding layer and the second bonding layer to form the cell including the cavity.

~~16.~~14. The method according to claim ~~15~~13,
wherein the first adhesion layer and the second adhesion layer comprise chromium or titanium.

~~17. The method according to claim 15,~~
~~wherein the first bonding layer and the second bonding layer comprise gold.~~

~~18.~~15. The method according to claim ~~12~~10,
wherein the first semiconductor substrate, the second semiconductor substrate and the one or more metal layers form a further cell including a further cavity.

~~19.~~16. The method according to claim ~~18~~15,
wherein the further cavity is sealed.

~~20.~~17. The method according to claim ~~18~~15,
wherein the first semiconductor substrate, the second semiconductor substrate and the one or more metal layers also define at least one further inlet for fluid to flow into the further cavity and at least one further outlet for fluid to flow out of the further cavity.