receive a reagent container, can be removably coupled to a reaction chamber. A delivery portion of the housing defines a delivery path between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber. The delivery path includes a protrusion such that the delivery path has a discontinuous inner surface. The actuator can be moved to convey a reagent from the reagent container into the reaction chamber via the delivery path.

In one aspect, the present invention refers to an apparatus, comprising:

- a reaction chamber (732, 1732, 2732, 3732);
- a housing (741, 1741, 2741, 3741) configured to be removably coupled to ~~a~~ the reaction chamber ~~(732, 1732, 2732, 3732)~~, the housing defining a reagent volume (742, 1742, 2742, 2744, 3742) configured to contain a reagent, the housing including a side wall (774, 2774) defining a delivery path (771, 1771, 2771, 2773, 3771) between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber having a delivery path length L, the side wall including a protrusion (776, 1776, 2776, 2778, 3776) within the delivery path, the housing further including an end surface (745, 1745, 2745) defining an exit opening (746, 2746) through which the reagent is conveyed when the reagent exits the delivery path into the reaction chamber; and
- an actuator (750, 1750, 2750, 2760, 3750) configured to be manipulated to convey the reagent from the reagent volume into the reaction chamber via the delivery path, wherein:
- the delivery path defines a longitudinal center line and a flow area, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a diameter; ~~and~~
- the protrusion extends into the flow area a distance (HP) from the side wall, a ratio of the distance to the diameter being between about 0.1 and 0.2;
- the protrusion extends into the exit opening; and
- the protrusion length (L_P) is substantially equal to or greater than the length L of the delivery path.

In ~~another aspect~~some examples, the present invention refers to an apparatus, comprising:

- a housing (741, 1741, 2741, 3741) configured to be removably coupled to a reaction chamber (732, 1732, 2732, 3732), the housing defining a reagent volume (742, 1742, 2742, 2744, 3742) configured to contain a reagent, the housing including delivery portion (1770, 2770, 2772, 3770) having a side wall (774, 2774) and an end surface (745, 1745, 2745), the side wall defining a delivery path (771, 1771, 2771, 2773, 3771) between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber, the

end surface defining an exit opening (746, 2746) through which an exit flow of the reagent is conveyed when exiting the delivery path; and

- an actuator (750, 1750, 2750, 2760, 3750) configured to be manipulated to produce the exit flow of the reagent, the delivery portion configured such that the exit flow of the reagent forms a plume that is detached from the end surface of the delivery portion,

wherein the side wall of the delivery portion defines a flow area along a path length within the delivery path, the flow area bounded by the side wall and being within a plane normal to a longitudinal center line of the delivery path, the delivery portion including a flow structure within the delivery path such that a shape of the flow area is discontinuous.

In ~~yet~~ another aspect, the present invention refers to a method, comprising:

- coupling a reagent module (710, 1710, 2710) to a sample container such that an end surface (745, 1745, 2745) of the reagent module covers a reaction chamber (732, 1732, 2732) defined by the sample container, the reaction chamber containing a sample, the reagent module including a housing (741, 1741, 2741, 3741) defining a reagent volume (742, 1742, 2742, 2744, 3742) containing a reagent, the housing including a side wall (774, 2774) defining a delivery path (771, 1771, 2771, 2773, 3771) between the reagent volume and the reaction chamber when the reagent module is coupled to the reaction chamber having a delivery path length L, the side wall including a protrusion (776, 1776, 2776, 2778, 3776) within the delivery path, the housing further including an end surface defining an exit opening through which the reagent is conveyed when the reagent exits the delivery path into the reaction chamber;
- disposing, after the coupling, at least a distal end portion of the sample container into an instrument (100, 2100); and
- actuating the instrument to:
  - produce a force on the reagent module to move at least the distal end portion of the sample container into a detection volume (2234) of the instrument; and
  - manipulate, when the distal end portion of the sample container is in the detection volume, the reagent module to convey the reagent from the reagent volume into the reaction chamber via the delivery path

wherein:

- the delivery path defines a longitudinal center line and a flow area, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a diameter (D); ~~and~~

- the protrusion extends into the flow area a distance from the side wall, a ratio of the distance to the diameter being between about 0.1 and 0.2;
- the protrusion extends into the exit opening; and
- the protrusion length (L_P) is substantially equal to or greater than the length L of the delivery path.

In one example an apparatus is provided comprising a housing configured to be removably coupled to a reaction chamber, the housing defining a reagent volume configured to contain a reagent, the housing including a side wall defining a delivery path between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber, the side wall including a protrusion within the delivery path; and an actuator configured to be manipulated to convey the reagent from the reagent volume into the reaction chamber via the delivery path. In some examples, the housing includes an end surface defining an exit opening through which the reagent is conveyed when the reagent exits the delivery path into the reaction chamber; and the protrusion extends into the exit opening. In some examples, the delivery path defines a longitudinal center line and has a path length; and the protrusion includes an edge parallel to the longitudinal center line, the edge having a protrusion length of at least ten percent of the path length. In some examples, the delivery path defines a longitudinal center line and has a path length; and the protrusion includes an edge parallel to the longitudinal center line, the edge having a protrusion length of at least half of the path length. In some examples, the protrusion length is substantially equal to the path length. In some examples, a flow area of the delivery path has a diameter; and the protrusion extends into the flow area a distance from the side wall, a ratio of the distance to the diameter being between about 0.1 and 0.2. In some examples, a flow area of the delivery path has a diameter and a path length, a ratio of the path length to the diameter being between about 2.5 and about 3.5. In some examples, the side wall includes a plurality of protrusions within the delivery path, the plurality of protrusions including the protrusion. In some examples, the delivery path defines a longitudinal center line; and the side wall includes a plurality of protrusions within the delivery path, the plurality of protrusions including the protrusion, the plurality of protrusions being equally spaced circumferentially about the longitudinal center line. In some examples, the actuator has a plunger portion and an engagement portion, the plunger portion disposed within the reagent volume, the engagement portion of the actuator configured to receive a force to move the plunger portion within the reagent volume. In some

CLAIMS

1. An apparatus, comprising:

- a reaction chamber (732, 1732, 2732, 3732);
- a housing (741, 1741, 2741, 3741) configured to be removably coupled to ~~a~~ the reaction chamber ~~(732, 1732, 2732, 3732)~~, the housing defining a reagent volume (742, 1742, 2742, 2744, 3742) configured to contain a reagent, the housing including a side wall (774, 2774) defining a delivery path (771, 1771, 2771, 2773, 3771) between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber having a delivery path length L, the side wall including a protrusion (776, 1776, 2776, 2778, 3776) within the delivery path, the housing further including an end surface (745, 1745, 2745) defining an exit opening (746, 2746) through which the reagent is conveyed when the reagent exits the delivery path into the reaction chamber; and
- an actuator (750, 1750, 2750, 2760, 3750) configured to be manipulated to convey the reagent from the reagent volume into the reaction chamber via the delivery path,

wherein:

- the delivery path defines a longitudinal center line and a flow area, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a diameter; and
- the protrusion extends into the flow area a distance (H_P) from the side wall, a ratio of the distance to the diameter being between about 0.1 and 0.2;
- the protrusion extends into the exit opening; and
- the protrusion length (L_P) is substantially equal to or greater than the length L of the delivery path.

~~2. The apparatus of claim 1, wherein the housing includes an end surface (745, 1745, 2745) defining an exit opening (746, 2746) through which the reagent is conveyed when the reagent exits the delivery path into the reaction chamber; and the protrusion extends into the exit opening.~~

~~3~~2. The apparatus of ~~any one of~~ claims 1 ~~or 2~~, wherein:

- the delivery path defines a longitudinal center line (CL) and has a path length (L); and

- the protrusion includes an edge (1761, 2762) parallel to the longitudinal center line, the edge having a protrusion length (L_P) of at least ten percent of the path length.

43. The apparatus of any one of claims 1 to ~~32~~, wherein:
- the delivery path defines a longitudinal center line and has a path length; and
- the protrusion includes an edge parallel to the longitudinal center line, the edge having a protrusion length of at least half of the path length.

~~5. The apparatus of claim 4, wherein the protrusion length is substantially equal to the path length.~~

64. The apparatus of any one of claims 1 to ~~53~~, wherein the delivery path defines a longitudinal center line, a path length, and a flow area, the path length being along the longitudinal center line, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a diameter, a ratio of the path length to the diameter being between about 2.5 and about 3.5.

75. The apparatus of any one of claims 1 to ~~64~~, wherein the side wall includes a plurality of protrusions (1771, 2771, 2778) within the delivery path, the plurality of protrusions including the protrusion.

86. The apparatus of any one of claims 1 to ~~75~~, wherein:
- the delivery path defines a longitudinal center line; and
- the side wall includes a plurality of protrusions within the delivery path, the plurality of protrusions including the protrusion, the plurality of protrusions being equally spaced circumferentially about the longitudinal center line.

97. The apparatus of any one of claims 1 to ~~86~~, wherein the actuator has a plunger portion (1754, 2754, 2756) and an engagement portion (1752, 2752, 2753), the plunger portion disposed within the reagent volume, the engagement portion of the actuator configured to receive a force to move the plunger portion within the reagent volume.

~~108~~. The apparatus of claim ~~97~~, further comprising:
- a reagent container (1780, 2780, 2790, 3780) disposed within the reagent volume, the reagent container containing the reagent and including a frangible portion (1788, 2788, 2789, 3788), the housing including a puncturer (1792, 2792, 2794, 3792) within the reagent volume, the puncturer having a sharp point configured to pierce the frangible portion of the reagent container; and

- the plunger portion of the actuator configured to contact the reagent container such that the puncturer punctures the frangible portion of the reagent container to convey the reagent from the reagent volume into the reaction chamber via the delivery path.

~~11~~9. The apparatus of claim ~~10~~8, further comprising:

- the reagent container disposed within the reagent volume, the reagent container containing the reagent formulated to react with a plurality of reporter molecules in a sample to enhance production of a signal.

~~12~~10. The apparatus of claim ~~11~~9, wherein the reagent is a first reagent, the apparatus further comprising:

- the reagent container disposed within the reagent volume, the reagent container containing the first reagent formulated to react with a plurality of reporter molecules in a sample to enhance production of a signal; and
- the reaction chamber containing a second reagent formulated to react with the sample to limit production of the signal.

~~13~~11. The apparatus of claim ~~12~~10, wherein the second reagent is formulated to sterilize the sample.

~~14. An apparatus, comprising:~~

~~a housing (741, 1741, 2741, 3741) configured to be removably coupled to a reaction chamber (732, 1732, 2732, 3732), the housing defining a reagent volume (742, 1742, 2742, 2744, 3742) configured to contain a reagent, the housing including delivery portion (1770, 2770, 2772, 3770) having a side wall (774, 2774) and an end surface (745, 1745, 2745), the side wall defining a delivery path (771, 1771, 2771, 2773, 3771) between the reagent volume and the reaction chamber when the housing is coupled to the reaction chamber, the end surface defining an exit opening (746, 2746) through which an exit flow of the reagent is conveyed when exiting the delivery path; and~~

~~an actuator (750, 1750, 2750, 2760, 3750) configured to be manipulated to produce the exit flow of the reagent, the delivery portion configured such that the exit flow of the reagent forms a plume that is detached from the end surface of the delivery portion,~~

~~wherein the side wall of the delivery portion defines a flow area along a path length within the delivery path, the flow area bounded by the side wall and being within a~~

~~plane normal to a longitudinal center line of the delivery path, the delivery portion including a flow structure within the delivery path such that a shape of the flow area is discontinuous.~~

~~15. The apparatus of claim 14, wherein:~~

~~the delivery path defines a longitudinal center line (CL) and a flow area, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a diameter (D); and~~

~~the plume is characterized by a plume width, a ratio of the plume width to the diameter being less than about 4.~~

~~16. The apparatus of any one of claims 14 or 15, wherein the side wall including a flow structure (776, 1776, 2776, 2778, 3776) within the delivery path, the flow structure positioned to contact the exit flow of the reagent.~~

~~17. The apparatus of claim16, wherein:~~

~~the delivery path defines a longitudinal center line and has a path length (L); and~~

~~the flow structure includes an edge (1761, 2762) parallel to the longitudinal center line, the edge having an edge length (L_P) of at least half of the path length.~~

~~18. The apparatus of any one of claims 16 to 17, wherein the side wall includes a plurality of protrusions (1771, 2771, 2778) within the delivery path, the plurality of protrusions being equally spaced circumferentially about a longitudinal center line of the flow path.~~

~~19~~12. A method, comprising:

- coupling a reagent module (710, 1710, 2710) to a sample container such that an end surface (745, 1745, 2745) of the reagent module covers a reaction chamber (732, 1732, 2732) defined by the sample container, the reaction chamber containing a sample, the reagent module including a housing (741, 1741, 2741, 3741) defining a reagent volume (742, 1742, 2742, 2744, 3742) containing a reagent, the housing including a side wall (774, 2774) defining a delivery path (771, 1771, 2771, 2773, 3771) between the reagent volume and the reaction chamber when the reagent module is coupled to the reaction chamber <u>having a delivery path length L</u>, the side wall including a protrusion (776, 1776, 2776, 2778, 3776) within the delivery path, <u>the housing further including an end surface defining an exit opening through which the reagent is conveyed when the reagent exits the delivery path into the reaction chamber</u>;

- disposing, after the coupling, at least a distal end portion of the sample container into an instrument (100, 2100); and
- actuating the instrument to:
  - produce a force on the reagent module to move at least the distal end portion of the sample container into a detection volume (2234) of the instrument; and
  - manipulate, when the distal end portion of the sample container is in the detection volume, the reagent module to convey the reagent from the reagent volume into the reaction chamber via the delivery path

wherein:

- the delivery path defines a longitudinal center line and a flow area, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a diameter (D); ~~and~~
- the protrusion extends into the flow area a distance from the side wall, a ratio of the distance to the diameter being between about 0.1 and 0.2;
- the protrusion extends into the exit opening; and
- the protrusion length (L_P) is substantially equal to or greater than the length L of the delivery path.

~~20~~13. The method of claim ~~19~~12, wherein the actuating the instrument to manipulate the reagent module includes moving an actuator (750, 1750, 2750, 2760, 3750) within the reagent volume to produce a flow of the reagent within the delivery path, the flow forming an exit plume upon exiting the delivery path into the reaction chamber, the exit plume being detached from the end surface of the reagent module.

~~21~~14. The method of any one of claims ~~19~~ 12 or ~~20~~13, wherein the actuating the instrument to manipulate the reagent module includes moving an actuator (750, 1750, 2750, 2760, 3750) at a speed within the reagent volume to produce a flow of the reagent within the delivery path, the speed such that the flow of the reagent is laminar.

~~22~~15. The method of any one of claims ~~19~~ 12 to ~~21~~14, wherein:

- the reagent is a solution containing tridecanal;
- the delivery path defines a longitudinal center line (CL) and a flow area, the flow area bounded by the side wall and being within a plane normal to the longitudinal center line, the flow area of the delivery path having a characteristic diameter (D); and

- the actuating the instrument to manipulate the reagent module includes moving an actuator at a speed within the reagent volume to produce a flow of the reagent within the delivery path, a viscosity of the solution, the characteristic diameter, and the speed being such that the flow of the reagent is laminar.

2316. The method of any one of claims ~~19~~ 12 to ~~22~~15, wherein the actuating the instrument to manipulate the reagent module includes moving an actuator at a speed within the reagent volume to produce a flow of the reagent within the delivery path, the speed being between about 30 mm/sec and about 50 mm/sec.

2417. The method of any one of claims ~~19~~ 12 to ~~23~~16, wherein:

- the reagent volume includes a reagent container (1780, 2780, 2790, 3780) containing the reagent;
- the housing includes a puncturer (1792, 2792, 2794, 3792) within the reagent volume; and

the actuating the instrument to manipulate the reagent module includes moving an actuator within the reagent volume to urge a frangible portion (1788, 2788, 2789, 3788) of the reagent container into contact with the puncturer to pierce the frangible portion and to produce a flow of the reagent within the delivery path.

2518. The method of any one of claims ~~19~~ 12 to ~~24~~17, wherein:

- the delivery path defines a longitudinal center line (CL) and has a path length (L); and
- the protrusion includes an edge (1761, 2762) parallel to the longitudinal center line, the edge having a protrusion length (L_P) of at least half of the path length.

2619. The method of any one of claims ~~19~~ 12 to ~~25~~18, wherein:

- the delivery path defines a longitudinal center line; and
- the side wall includes a plurality of protrusions (1771, 2771, 2778) within the delivery path, the plurality of protrusions including the protrusion, the plurality of protrusions being equally spaced circumferentially about the longitudinal center line.