Claims

1. (Amended) A discharge device comprising a discharge head that discharges a liquid material from a nozzle opening connected to a cavity in air toward a target by varying the internal pressure of the cavity using an actuator,

wherein the discharge head includes a monitoring portion that is light transmissive and is provided between the cavity and the nozzle opening, the monitoring portion including a part connected to the nozzle opening that holds the liquid material to be discharged next from the nozzle opening,

and the discharge device further comprises:

a detection apparatus that includes an image pickup unit that carries out image recognition using light on particle-like bodies included in the liquid material in the monitoring portion, the detection apparatus detecting a number of the particle-like bodies included in the liquid material to be discharged next from the nozzle opening in the part connected to the nozzle opening in a state immediately before discharge where vibration of a meniscus of the liquid material formed at the nozzle opening has been caused to attenuate; and

a control apparatus that changes, in the part connected to the nozzle opening, a number of the particle-like bodies included in the liquid material to be discharged next from the nozzle opening to a predetermined condition by driving the actuator according to a detection result of the detection apparatus to apply, to the cavity, pressure in a range that does not cause the liquid material to be discharged or pressure in a range that causes the liquid material to be discharged in the air.

2. The discharge device according to claim 1,

wherein the monitoring portion includes a flattened portion where a cross section of a flow path from the cavity to the nozzle opening of the discharge head extends like oblate in a first direction, the flattened portion dispersing the particle-like bodies in the first direction.

3. The discharge device according to claim 2,

wherein the nozzle opening is flattened so as to extend in the first direction.

4. (Deleted)

5. (Deleted)

6. (Amended) The discharge device according to any one of claims 1 to 3,

wherein the control apparatus includes a function that changes a discharge target of the liquid material according to the detection result.

7. The discharge device according to claim 6,

wherein the function that changes the discharge target includes a function that disposes of the liquid material.

8 (Amended). The discharge device according to any one of claims 1 to 3, 6, and 7,

wherein the monitoring portion includes a first region that is connected to the nozzle opening and a second region that follows the first region,

the detection apparatus acquires the number in the first region of the monitoring portion and the number in the second region, and

the control apparatus is operable, when the detection result of the first region is outside a range of a predetermined condition or when the detection result of the second region is outside a range of a predetermined condition, to change the number of the particle-like bodies included in the liquid material in the monitoring portion.

9. (Amended) The discharge device according to any one of claims 1 to 3 and 6 to 8,

wherein the actuator is a piezo element, and

the control apparatus includes a feature that supplies drive pulses of a pushing type to the piezo element when the liquid material is to be discharged.

10. (Deleted)

11. (Deleted)

12. The discharge device according to claim 2,

wherein a maximum height $\boldsymbol{h}$ in a second direction that is perpendicular to the first direction inside the flattened portion and an average particle diameter $\boldsymbol{r}$ of the particle-like bodies satisfy a condition that $1.2 \leq \boldsymbol{h}/\boldsymbol{r} \leq 100.0$.

13. The discharge device according to claim 12,

wherein the maximum height $\boldsymbol{h}$ and an internal diameter $\boldsymbol{d}$ of

the nozzle opening satisfy a condition that $0.5 \leq h/d \leq 20.0$.

14. (Amended) The discharge device according to any one of claims 1 to 3, 6 to 9, 12, and 13,

wherein the monitoring portion includes a first side wall and a second side wall that are flat and disposed facing one another.

15. (Amended) The discharge device according to any one of claims 1 to 3, 6 to 9, and 12 to 14,

further comprising a tubular member that holds the liquid material and part of which is shaped so as to form the cavity whose internal pressure is varied by an actuator attached to an outside, the nozzle opening being provided at one end of the tubular member,

wherein the monitoring portion is provided between the cavity and the nozzle opening of the tubular member.

16. The discharge device according to claim 15,

wherein the monitoring portion is a part molded by squeezing part of the tubular member from the outside.

17. The discharge device according to claim 15 or 16,

wherein the tubular member is one of a glass tube, a resin tube, and a ceramic tube that is light transmissive.

18. (Amended) A method of discharging a liquid material including particle-like bodies onto a target using a discharge device,

Wherein the discharge device includes a discharge head that discharges the liquid material from a nozzle opening connected to the cavity in air toward the target by varying the internal pressure of a cavity using an actuator, a control apparatus that controls the actuator, and a detection apparatus that includes an image pickup unit that carries out image recognition using light on particle-like bodies included in the liquid material in a part connected to the nozzle opening of a light transmissive monitoring portion provided between the cavity and the nozzle opening, the part connected to the nozzle opening holding the liquid material to be discharged next from the nozzle opening,

the method comprising:

the control apparatus acquiring a detection result, from the detection apparatus, including a number of the particle-like bodies included in the liquid material to be discharged next from the nozzle opening in the part connected to the nozzle opening in a state immediately before discharge where vibration of a meniscus of the liquid material formed at the nozzle opening has been caused to

attenuate; and

changing, in the part connected to the nozzle opening, a number of the particle-like bodies included in the liquid material to be discharged next from the nozzle opening to a predetermined condition by driving the actuator according to the detection result to apply, to the cavity, pressure in a range that does not cause the liquid material to be discharged or pressure in a range that causes the liquid material to be discharged in the air.

19. (Deleted)

20. (Amended) The method according to claim 18,

wherein the changing the number to the predetermined condition includes changing a discharge target of the liquid material according to the detection result.

21. The method according to claim 20,

wherein the changing a discharge target includes disposing of the liquid material.

22. (Amended) The method according to any one of claims 18, 20, and 21,

wherein the acquiring the detection result includes setting, in the monitoring portion, a first region that is connected to the nozzle opening and a second region that follows the first region, and acquiring the detection result for the first region and the detection result for the second region, and

the changing the number to the predetermined condition includes changing the number of the particle-like bodies included in the liquid material in the monitoring portion when the detection result of the first region is outside a range of a predetermined condition or when the detection result of the second region is outside a range of a predetermined condition.

23. (Amended) The method according to any one of claims 18 and 20 to 22,

wherein the actuator is a piezo element, and

the method comprises the control apparatus supplying drive pulses of a pushing type to the piezo element when the liquid material is to be discharged.

24. The method according to any one of claims 18 and 20 to 23, wherein the control apparatus includes discharging a volume ***q*** of the liquid material in one discharge from the nozzle opening that

satisfies a condition $0.0001 \leq \boldsymbol{D} \times \boldsymbol{q} \leq 3.0$, where $\boldsymbol{D}$ is a number of the particle-like bodies included in a unit volume of the liquid material.

25. (Amended) The method according to any of claims 18 and 20 to 24,

wherein the discharge device includes an apparatus that picks up an image of a droplet discharged from the nozzle opening and carries out image analysis, and

the method further comprises the apparatus that carries out image analysis determining whether the particle-like bodies are included in the droplet discharged from the nozzle opening.

Claims

1. A discharge device comprising a discharge head that discharges a liquid material from a nozzle opening connected to a cavity in air toward a target by varying the internal pressure of the cavity using an actuator,

wherein the discharge head includes a monitoring portion that is light transmissive and is provided between the cavity and the nozzle opening, the monitoring portion including a part connected to the nozzle opening that holds the liquid material to be discharged next from the nozzle opening,

and the discharge device further comprises:

a detection apparatus that includes an image pickup unit that carries out image recognition using light on particle-like bodies included in the liquid material in the monitoring portion, the detection apparatus detecting a number of the particle-like bodies included in the liquid material to be discharged next from the nozzle opening in the part connected to the nozzle opening in a state immediately before discharge where vibration of a meniscus of the liquid material formed at the nozzle opening has been caused to attenuate; and

a control apparatus that changes, in the part connected to the nozzle opening, a number of the particle-like bodies included in the liquid material to be discharged next from the nozzle opening to a predetermined condition by driving the actuator according to a detection result of the detection apparatus to apply, to the cavity, pressure in a range that does not cause the liquid material to be discharged or pressure in a range that causes the liquid material to be discharged in the air.

2. The discharge device according to claim 1,

wherein the monitoring portion includes a flattened portion where a cross section of a flow path from the cavity to the nozzle opening of the discharge head extends like oblate in a first direction, the flattened portion dispersing the particle-like bodies in the first direction.

3. The discharge device according to claim 2,

wherein the nozzle opening is flattened so as to extend in the first direction.

4. The discharge device according to any one of claims 1 to 3,

wherein the control apparatus includes a function that changes a discharge target of the liquid material according to the

detection result.

5. The discharge device according to claim 4,
wherein the function that changes the discharge target includes a function that disposes of the liquid material.

6. The discharge device according to any one of claims 1 to 3, 4, and 5,
wherein the monitoring portion includes a first region that is connected to the nozzle opening and a second region that follows the first region,
the detection apparatus acquires the number in the first region of the monitoring portion and the number in the second region, and
the control apparatus is operable, when the detection result of the first region is outside a range of a predetermined condition or when the detection result of the second region is outside a range of a predetermined condition, to change the number of the particle-like bodies included in the liquid material in the monitoring portion.

7. The discharge device according to any one of claims 1 to 3 and 4 to 6,
wherein the actuator is a piezo element, and
the control apparatus includes a feature that supplies drive pulses of a pushing type to the piezo element when the liquid material is to be discharged.

8. The discharge device according to claim 2,
wherein a maximum height $\boldsymbol{h}$ in a second direction that is perpendicular to the first direction inside the flattened portion and an average particle diameter $\boldsymbol{r}$ of the particle-like bodies satisfy a condition that $1.2 \leq \boldsymbol{h}/\boldsymbol{r} \leq 100.0$.

9. The discharge device according to claim 8,
wherein the maximum height $\boldsymbol{h}$ and an internal diameter $\boldsymbol{d}$ of the nozzle opening satisfy a condition that $0.5 \leq \boldsymbol{h}/\boldsymbol{d} \leq 20.0$.

10. The discharge device according to any one of claims 1 to 3, 4 to 7, 8, and 9,
wherein the monitoring portion includes a first side wall and a second side wall that are flat and disposed facing one another.

11. The discharge device according to any one of claims 1 to 3, 4 to 7, and 8 to 10,

further comprising a tubular member that holds the liquid material and part of which is shaped so as to form the cavity whose internal pressure is varied by an actuator attached to an outside, the nozzle opening being provided at one end of the tubular member,

wherein the monitoring portion is provided between the cavity and the nozzle opening of the tubular member.

12. The discharge device according to claim 11,

wherein the monitoring portion is a part molded by squeezing part of the tubular member from the outside.

13. The discharge device according to claim 11 or 12,

wherein the tubular member is one of a glass tube, a resin tube, and a ceramic tube that is light transmissive.

14. A method of discharging a liquid material including particle-like bodies onto a target using a discharge device,

Wherein the discharge device includes a discharge head that discharges the liquid material from a nozzle opening connected to the cavity in air toward the target by varying the internal pressure of a cavity using an actuator, a control apparatus that controls the actuator, and a detection apparatus that includes an image pickup unit that carries out image recognition using light on particle-like bodies included in the liquid material in a part connected to the nozzle opening of a light transmissive monitoring portion provided between the cavity and the nozzle opening, the part connected to the nozzle opening holding the liquid material to be discharged next from the nozzle opening,

the method comprising:

the control apparatus acquiring a detection result, from the detection apparatus, including a number of the particle-like bodies included in the liquid material to be discharged next from the nozzle opening in the part connected to the nozzle opening in a state immediately before discharge where vibration of a meniscus of the liquid material formed at the nozzle opening has been caused to attenuate; and

changing, in the part connected to the nozzle opening, a number of the particle-like bodies included in the liquid material to be discharged next from the nozzle opening to a predetermined condition by driving the actuator according to the detection result to apply, to the cavity, pressure in a range that does not cause the liquid material to be discharged or pressure in a range that causes the liquid material to be discharged in the air.

15. The method according to claim 14,
wherein the changing the number to the predetermined condition includes changing a discharge target of the liquid material according to the detection result.

16. The method according to claim 15,
wherein the changing a discharge target includes disposing of the liquid material.

17. The method according to any one of claims 14, 15, and 16,
wherein the acquiring the detection result includes setting, in the monitoring portion, a first region that is connected to the nozzle opening and a second region that follows the first region, and acquiring the detection result for the first region and the detection result for the second region, and
the changing the number to the predetermined condition includes changing the number of the particle-like bodies included in the liquid material in the monitoring portion when the detection result of the first region is outside a range of a predetermined condition or when the detection result of the second region is outside a range of a predetermined condition.

18. The method according to any one of claims 14 and 15 to 17,
wherein the actuator is a piezo element, and
the method comprises the control apparatus supplying drive pulses of a pushing type to the piezo element when the liquid material is to be discharged.

19. The method according to any one of claims 14 and 15 to 18,
wherein the control apparatus includes discharging a volume $\boldsymbol{q}$ of the liquid material in one discharge from the nozzle opening that satisfies a condition $0.0001 \leq \boldsymbol{D} \times \boldsymbol{q} \leq 3.0$, where $\boldsymbol{D}$ is a number of the particle-like bodies included in a unit volume of the liquid material.

20. The method according to any of claims 14 and 15 to 19,
wherein the discharge device includes an apparatus that picks up an image of a droplet discharged from the nozzle opening and carries out image analysis, and
the method further comprises the apparatus that carries out image analysis determining whether the particle-like bodies are included in the droplet discharged from the nozzle opening.