

Method for Cleaning Lithium-Niobate Single-sided Polished Wafer

Cross-reference to Related Applications

[001] The present disclosure claims the priority to the Chinese patent application with the filling No. CN202210407079.4 filed with the Chinese Patent Office on April 19, 2022, and entitled “Method for Cleaning Lithium-Niobate Single-sided Polished Wafer”, the contents of which are incorporated herein by reference in entirety.

Technical Field

[002] The present disclosure belongs to the field of cleaning semiconductor material and specifically relates to a method for cleaning lithium-niobate single-sided polished wafer, which is semiconductor material.

[003] Background Art

[004] Lithium niobate is a multifunctional material that combines functions such as piezoelectricity, ferroelectricity, pyroelectricity, nonlinearity, photoelectricity, photoelasticity, and photo refraction. Due to its excellent physical property, lithium niobate has attracted increasing attention and has been widely used in fields such as aviation, aerospace, and civilian optoelectronic products. Polished lithium niobate substrates are widely used in sensors, acousto-optic devices, optical gyroscopes, and more. Unlike silicon wafers and sapphire wafers, its characteristic is extremely low fracture toughness, thereby making lithium niobate wafers prone to fragmentation during the cleaning process, and resulting in high production costs for enterprises.

[005] With the development and advancement of IC design and manufacturing technologies, the requirements for surface cleanliness of lithium niobate wafers have been continuously increasing. However, lithium niobate wafers possess strong electrostatic adsorption capability, thereby making it difficult to handle the particles on the surface of wafer. Particle contamination on the surface of lithium niobate wafers can have a direct impact on subsequent processes such as gluing and coating, which will lead to wafer defects. Therefore, it is necessary not only to ensure clean protection during packaging and transportation but also to achieve high cleanliness and excellent quality from the source of the product, so as to enable lithium niobate wafers to meet the high requirements for surface cleanliness. The wafer cleaning process, as the main procedure for removing particle contamination from the surface of the wafer, plays a crucial role in maintaining high surface cleanliness of the lithium niobate wafers. However, during the cleaning process, lithium niobate wafers are prone to fragmentation, which poses significant challenges for the subsequent processing of the wafers. Therefore, there is an urgent need to develop a cleaning method that offers high cleanliness and a low fragment rate.

[006] The invention patent with the patent number CN101661869B discloses a method for cleaning gallium arsenide wafers after polishing, which utilizes a high-temperature cleaning process with the concentrated sulfuric acid to achieve the purpose of removing surface contaminants from the wafers.

However, when cleaning lithium niobate wafers, the high-temperature cleaning with the concentrated sulfuric acid can easily lead to corrosion and fragmentation of the wafers due to the strong acid. Additionally, the acidic solution tends to evaporate during the processing, which poses potential safety hazards for both environment and human health. Furthermore, the traditional cleaning method of soaking in sulfuric acid combined with cleaning agents is ineffective in cleaning particle contamination on the wafer surface.

[007] The invention patent with the patent number CN102479669B discloses a wafer brush cleaning device and a wafer brush cleaning method, which employs a dual-sided brush cleaning approach to achieve the purpose of removing particles on wafer. However, in practice, relying solely on the approach of dual-sided brush cleaning and translational motion has limited cleaning effectiveness, which can only remove larger particles from the wafer surface and cannot meet the requirements for achieving high cleanliness.

[008] Therefore, existing technologies lack a cleaning method for lithium niobate wafers that can achieve both low fragment rate and high cleanliness.

[009] Summary

[010] The present disclosure provides a cleaning method for lithium-niobate single-sided polished wafer to address the shortcomings of existing technologies. The cleaning process of this method is stable, which results in high surface cleanliness of the wafers with a low cleaning fragment rate.

[011] The technical solution adopted to address the issue in the present disclosure is as follows. A method for cleaning lithium-niobate single-sided polished wafer comprises the following steps:

- (a) soaking the lithium niobate wafer in ammonium hydrogen fluoride dilution solution at 30-40°C for 10-30 minutes to remove residual silica polishing slurry from the surface of the polished wafer, and then rinsing the wafer in pure water at 30-40°C for 3-5 minutes;
- (b) preheating and soaking the lithium niobate wafer treated in step (a) in pure water at 55-65 °C for 1-3 minutes; and then placing the wafer in an organic solvent cleaning solution at 70-80 °C for ultrasonic cleaning for 10-20 minutes to remove organic contamination and heavy metal ion contamination from the wafer surface;
- (c) placing the lithium niobate wafer treated in step (b) into a deionized water rinse tank, performing processes of spraying, water injection, overflowing, and fast-draining, and repeating the processes 4-6 times, so as to remove residual cleaning agents from the wafer surface;
- (d) brushing the lithium niobate wafer treated in step (c) with a dual-sided brush in an alkaline cleaning solution, then conducting brushing by a dual-sided brush and spraying rinsing in deionized water; and performing a spin-drying process;
- (e) attaching a backside of the lithium niobate wafer treated in step (d) to a vacuum platform; conducting brushing by single-sided brush with the

polished side facing up, while simultaneously conducting two-fluid spraying; and then rinsing with deionized water and carrying out a spin-drying process, to ensure that the number of particles not less than 0.3 μm on the wafer surface do not exceed 30.

[012] In the aforementioned step (a), by the heating-and-soaking process with ammonium hydrogen fluoride dilution solution, the residual silica polishing slurry is removed from the surface of the polished wafer, which prevents stubborn contamination caused by crystallization of the polishing slurry while not damaging the polished surface.

[013] Optionally, in step (a), the mass fraction of ammonium hydrogen fluoride is 98%, and the ammonium hydrogen fluoride dilution solution is prepared by mixing pure water and ammonium hydrogen fluoride in a mass ratio of 10-15: 1.

[014] In the aforementioned step (b), by the heated ultrasonic cleaning process with an organic solvent cleaning solution, the organic contamination and heavy metal ion contamination are removed from the wafer surface. This approach replaces the cleaning method of corrosive by concentrated sulfuric acid, thereby avoiding the issue of wafer fragmentation caused by strong acid corrosion. The ultrasonic frequency is 40 kHz.

[015] Optionally, in step (b), the organic solvent cleaning solution is prepared by mixing pure water and organic solvent cleaning agent in a volume ratio of 5-10: 1. The mass ratio of each of the components in the organic solvent cleaning agent is: isopropanolamine 15-20%, N-methylpyrrolidone 30-40%, potassium hydroxide 3-10%, and pure water 40-60%.

[016] In the aforementioned step (c), the four steps of spraying, water injection, overflowing, and fast-draining are used to repeat the cleaning process, for removing micro-particle impurities and residual cleaning solution on the wafer surface.

[017] Optionally, in step (c), the spraying time is 50-70s, the water injection volume submerges the wafer, an overflowing time is 20-30s, and a fast-draining time is 10s. The above processes are repeated for 4-6 times.

[018] In the aforementioned step (d), the dual-sided brush is used to perform the brushing process. This approach removes large particles from the front polished surface of the wafer, thereby reducing the burden of particle contamination accumulation from single-sided brushing. Additionally, it removes large particles from the backside of the wafer, thereby preventing the granularity of the polished surface from being affected by large particles on the backside of the wafer during subsequent processing and operation. The dual-sided brushing is a method using a dual-sided transmission rolling brush, where the brushes rotate and move the wafers in a translational motion.

[019] Optionally, in step (d), the dual-sided brushing employs a method using a dual-sided transmission rolling brush, where the brushes rotate and move the wafers in a translational motion. The brushes used for dual-sided brushing are roller brushes made of PVA. A brush rotation speed is 6-10 rpm. A pressing

distance of the upper and lower brushes is 1000-1300 μm . A brushing time is 3-5 minutes. A brush diameter is 2-3 cm. A spraying rinsing time is 10-20 s. A rotation speed for wafer spin-drying is 1200-1500 rpm. A spin-drying time is 15-20s.

[020] Optionally, in step (d), the alkaline cleaning solution is prepared by mixing deionized water and alkaline cleaning agent in a volume ratio of 30-50: 1. The mass ratio of each of the components in the alkaline cleaning agent is sodium hydroxide 0.2-0.6%, potassium hydroxide 1-3%, chelating agent 0.5-2%, non-ionic surfactant 2-5%, and deionized water 90-96%.

[021] In the aforementioned step (e), the polished surface of the lithium niobate wafer undergoes brushing process by the single-sided brush, with simultaneous two-fluid spraying performed. Then rinsing with deionized water and a spin-drying process are performed. The brushing process directly affects the fragment rate of the wafer during brushing and the cleanliness of the wafer after brushing.

[022] Optionally, in step (e), the brush used for single-sided brushing is a gyroscope-type brush made of PVA. A distance of pressing by the brush ranges from 900 to 1200 μm . A rotation speed of the brush is 1000-1500 rpm. A translational speed of the brush is 15-20 mm/s. The brush pauses at the center of the wafer for 0.5-1s. The brush pauses at the edges of the wafer for 3-5s. A brushing rotation speed of the wafer is 300-600 rpm. The brush moves back and forth 3-5 times for brushing. The rinsing with deionized water takes 5-10s. A rotation speed for wafer spin-drying is 3000-4000 rpm. A spin-drying time is 25-30s.

[023] Compared with the prior art, the present disclosure has the following beneficial technical effects.

[024] The cleaning method solves the problem of crystallization of the polishing slurry remaining on the wafer surface after the silica polishing slurry is used for polishing the lithium niobate wafer.

[025] The cleaning method replaces the approach of using a mixed cleaning solution of concentrated sulfuric acid and hydrogen peroxide for wafer cleaning, thereby avoiding the problems of strong acid corrosion and wafer fragmentation caused by concentrated sulfuric acid. Additionally, it prevents the problems of the safety risks posed by the volatility of acid solutions to the environment and to human health during processing.

[026] The cleaning method solves the problem of poor cleaning effect for particle contamination on wafer surfaces using traditional cleaning methods such as acetone, anhydrous ethanol ultrasonic cleaning, and RCA cleaning.

Brief Description of Drawings

[027] FIG. 1 is the processing flowchart of the present disclosure;

[028] FIG. 2 is a schematic diagram of the relationship between a process of preheating and soaking in pure water and the fragmentation rate in Examples 1, 2, and 3 of the present disclosure;

[029] FIG. 3 is a schematic diagram of the relationship between the ratio of alkaline cleaning solution and granularity in Examples 4, 5, and 6 of the present disclosure;

[030] FIG. 4 is a schematic diagram of the relationship between a distance of downward pressing of the brush, a fragmentation rate, and the granularity in Examples 7, 8, and 9 of the present disclosure; and

[031] FIG. 5 is a schematic diagram of the relationship between the brush pausing at the edge of the wafer and the granularity in Examples 8, 10, 11, and 12 of the present disclosure.

Detailed Description of Embodiments

[032] Further explanations of the present disclosure are provided through the following embodiments, but these embodiments should not be taken to limit the scope of protection of the present disclosure. The processing flowchart of the embodiments is shown in FIG. 1, wherein Examples 1-3 comprise only the first two steps, Examples 4-6 comprise the first four steps, and Examples 7-12 represent the complete cleaning processing flowchart.

[033] Example 1

- (a) The ammonium hydrogen fluoride dilution solution was prepared by mixing pure water and ammonium hydrogen fluoride in a mass ratio of 12: 1. The lithium niobate wafer was soaked in the ammonium hydrogen fluoride dilution solution at 35 °C for 15 minutes, then the wafer was rinsed in pure water at 35 °C for 3 minutes.
- (b) The organic solvent cleaning agent was prepared by mixing the following components in corresponding mass fractions: isopropanolamine 18%, N-methylpyrrolidone 35%, potassium hydroxide 4%, and pure water 43%. The pure water and the organic solvent cleaning agent were mixed in a volume ratio of 8: 1 to create the organic solvent cleaning solution. Without preheating the wafer in pure water, the lithium niobate wafer was placed into the organic solvent cleaning solution at 75°C for 40 kHz ultrasonic cleaning for 15 minutes. With 1273 wafers processed, 12 wafers fractured, with a fragment rate of 1.02%.

[034] Example 2

- (a) It was same as Example 1.
- (b) The organic solvent cleaning agent was prepared by mixing the following components in corresponding mass fractions: isopropanolamine 18%, N-methylpyrrolidone 35%, potassium hydroxide 4%, and pure water 43%. The pure water and the organic solvent cleaning agent were mixed in a volume ratio of 8: 1 to create the organic solvent cleaning solution. The lithium niobate wafer was preheated and soaked in the pure water at 60 °C for 2 minutes, then, the wafer was placed into the organic solvent cleaning solution at 75 °C

for 40 kHz ultrasonic cleaning for 15 minutes. With 1677 wafers processed, 4 wafers fractured, with a fragment rate of 0.24%.

[035] Example 3

- (a) It was same as Example 1.
- (b) The organic solvent cleaning agent was prepared by mixing the following components in corresponding mass fractions: isopropanolamine 18%, N-methylpyrrolidone 35%, potassium hydroxide 4%, and pure water 43%. The pure water and the organic solvent cleaning agent were mixed in a volume ratio of 8: 1 to create the organic solvent cleaning solution. The lithium niobate wafer was preheated and soaked in the pure water at 75 °C for 2 minutes, then, the wafer was placed into the organic solvent cleaning solution at 75°C for 40 kHz ultrasonic cleaning for 15 minutes. With 1412 wafers processed, 11 wafers fractured, with a fragment rate of 0.78%.

[036] Comparing Examples 1, 2, and 3, as shown in Table 1 and FIG. 2, preheating and soaking the wafer in pure water at 60°C for 2 minutes before performing high-temperature ultrasonic cleaning at 75°C with the organic solvent cleaning solution can effectively reduce wafer fragmentation caused by thermal shock.

[037] Table 1 Fragmentation Rate of Wafer Cleaning for Examples 1, 2, and 3

Test Item	Example 1	Example 2	Example 3
Fragmentation rate	0.94%	0.24%	0.78%

[038] Example 4

- (a) It was same as Example 2.
- (b) It was same as Example 2.
- (c) The lithium niobate wafer was placed into a deionized water rinse tank and subjected to the following steps: spraying for 60s, water injection to submerge the wafer, overflowing for 30s, and fast-draining for 10s. The processes were repeated 5 times.
- (d) The alkaline cleaning agent was prepared by mixing the following components in corresponding mass fractions: sodium hydroxide 0.4%, potassium hydroxide 2%, chelating agent 1.2%, non-ionic surfactant 4%, and deionized water 92.4%. Deionized water and the alkaline cleaning agent were mixed in a volume ratio of 25: 1 to create the alkaline cleaning solution. The lithium niobate wafer was first subjected to brushing by dual-sided brush in the alkaline cleaning solution, followed by brushing of dual-sided brush and spraying rinsing using deionized water. During brushing, a brush rotation speed was 6 rpm, the pressing distance of the upper and lower brushes was 1200 μm, a brushing time was 3 minutes, a brush diameter was 2.2 cm, and a spraying rinsing

time was 14s. Then, a spin-drying process was carried out, with the rotation speed for wafer spin-drying of 1300 rpm and the spin-drying time of 18s. With 764 wafers processed, 62 wafers were sampled, and the number of particles $\geq 0.3\mu\text{m}$ was smaller than or equal to 314.

[039] Example 5

- (a) It was same as Example 2.
- (b) It was same as Example 2.
- (c) It was same as Example 4.
- (d) The alkaline cleaning agent was prepared by mixing the following components in corresponding mass fractions: sodium hydroxide 0.4%, potassium hydroxide 2%, chelating agent 1.2%, non-ionic surfactant 4%, and deionized water 92.4%. Deionized water and the alkaline cleaning agent were mixed in a volume ratio of 40: 1 to create the alkaline cleaning solution. The lithium niobate wafer was first subjected to brushing by dual-sided brush in the alkaline cleaning solution, followed by brushing of dual-sided brush and spraying rinsing using deionized water. During brushing, a brush rotation speed was 6 rpm, the pressing distance of the upper and lower brushes was 1200 μm , a brushing time was 3 minutes, a brush diameter was 2.2 cm, and a spraying rinsing time was 14s. Then, a spin-drying process was carried out, with the rotation speed for wafer spin-drying of 1300 rpm and the spin-drying time of 18s. With 827 wafers processed, 67 wafers were sampled, and the number of particles $\geq 0.3\mu\text{m}$ was smaller than or equal to 169.

[040] Example 6

- (a) It was same as Example 2.
- (b) It was same as Example 2.
- (c) It was same as Example 4.
- (d) The alkaline cleaning agent was prepared by mixing the following components in corresponding mass fractions: sodium hydroxide 0.4%, potassium hydroxide 2%, chelating agent 1.2%, non-ionic surfactant 4%, and deionized water 92.4%. Deionized water and the alkaline cleaning agent were mixed in a volume ratio of 60: 1 to create the alkaline cleaning solution. The lithium niobate wafer was first subjected to brushing by dual-sided brush in the alkaline cleaning solution, followed by brushing of dual-sided brush and spraying rinsing using deionized water. During brushing, a brush rotation speed was 6 rpm, the pressing distance of the upper and lower brushes was 1200 μm , a brushing time was 3 minutes, a brush diameter was 2.2 cm, and a spraying rinsing time was 14s. Then, a spin-drying process was carried out, with the rotation speed for wafer spin-drying of 1300 rpm and the spin-drying time of 18s. With 883 wafers processed, 71 wafers were sampled, and the number of particles $\geq 0.3\mu\text{m}$ was smaller than or equal to 204.

[041] Comparing Examples 4, 5, and 6, as shown in Table 2 and FIG. 3, when creating the alkaline cleaning solution by mixing deionized water and the alkaline cleaning agent in a volume ratio of 40: 1, the wafer subjected to brushing by dual-sided brush has a higher cleanliness.

[042] Table 2 Fragmentation Rate and Granularity of Wafer Subjected to Single-Sided Brushing in Examples 4, 5, and 6

Test Item	Example 4	Example 5	Example 6
particles $\geq 0.3\mu\text{m}$	≤ 314	≤ 169	≤ 204

[043] Example 7

- (a) It was same as Example 2.
- (b) It was same as Example 2.
- (c) It was same as Example 4.
- (d) It was same as Example 5.
- (e) The polished surface of the lithium niobate wafer was subjected to brushing process by single-sided brush, with simultaneous dual-fluid spraying performed during brushing. When brushing, the distance of downward pressing of the brush was 600 μm , the brush rotation speed was 1300 rpm, and a translational speed of the brush was 17 mm/s. The brush paused at the center of the wafer for 1s. The brush paused at the edges of the wafer for 1s. The brushing rotation speed of the wafer was 400 rpm. The brush moved back and forth for 5 times for brushing. Then, an 8-second deionized water rinsing was conducted, followed by wafer spin-drying at a rotation speed of 3500 rpm for 26s. With 922 wafers processed, 0 wafers fractured, with a fragment rate of 0%. Among the 74 wafers sampled, the number of particles $\geq 0.3 \mu\text{m}$ was smaller than or equal to 97.

[044] Example 8

- (a) It was same as Example 2.
- (b) It was same as Example 2.
- (c) It was same as Example 4.
- (d) It was same as Example 5.
- (e) The polished surface of the lithium niobate wafer was subjected to brushing process by single-sided brush, with simultaneous dual-fluid spraying performed during brushing. When brushing, the distance of downward pressing of the brush was 1000 μm , the brush rotation speed was 1300 rpm, and a translational speed of the brush was 17 mm/s. The brush paused at the center of the wafer for 1s. The brush paused

at the edges of the wafer for 1s. The brushing rotation speed of the wafer was 400 rpm. The brush moved back and forth 5 times for brushing. Then, an 8-second deionized water rinsing was conducted, followed by wafer spin-drying at a rotation speed of 3500 rpm for 26s. With 1002 wafers processed, 1 wafer fractured, with a fragment rate of 0.10%. Among the 81 wafers sampled, the number of particles $\geq 0.3 \mu\text{m}$ was smaller than or equal to 47.

[045] Example 9

- (a) It was same as Example 2.
- (b) It was same as Example 2.
- (c) It was same as Example 4.
- (d) It was same as Example 5.
- (e) The polished surface of the lithium niobate wafer was subjected to brushing process by single-sided brush, with simultaneous dual-fluid spraying performed during brushing. When brushing, the distance of downward pressing of the brush was 1400 μm , the brush rotation speed was 1300 rpm, and a translational speed of the brush was 17 mm/s. The brush paused at the center of the wafer for 1s. The brush paused at the edges of the wafer for 1s. The brushing rotation speed of the wafer was 400 rpm. The brush moved back and forth for 5 times. Then, an 8-second deionized water rinsing was conducted, followed by wafer spin-drying at a rotation speed of 3500 rpm for 26 seconds. With 1161 wafers processed, 5 wafers fractured, with a fragment rate of 0.58%. Among the 93 wafers sampled, the number of particles $\geq 0.3 \mu\text{m}$ was smaller than or equal to 39.

[046] Comparing Examples 7, 8, and 9, as shown in Table 3 and FIG. 4, with the increased distance of downward pressing of the brush during single-sided brushing, the cleanliness of the wafer after brushing improves. However, a larger distance of downward pressing of the brush also leads to an increase in the proportion of fragmented wafers during brushing. When the distance of downward pressing of the brush during brushing is set at 1000 μm , the cleaning process yields a low fragment rate and high cleanliness.

[047] Table 3 Fragmentation Rate and Granularity of Wafer Subjected to Single-Sided Brushing in Examples 7, 8, and 9

Test Item	Example 7	Example 8	Example 9
fragmentation rate	0.00%	0.10%	0.58%
particles $\geq 0.3\mu\text{m}$	≤ 97	≤ 47	≤ 39

[048] Example 10

- (a) It was same as Example 2.
- (b) It was same as Example 2.
- (c) It was same as Example 4.
- (d) It was same as Example 5.
- (e) The polished surface of the lithium niobate wafer was subjected to brushing process by single-sided brush, with simultaneous dual-fluid spraying performed during brushing. When brushing, the distance of downward pressing of the brush was 1000 μm , the brush rotation speed was 1300 rpm, and a translational speed of the brush was 17 mm/s. The brush paused at the center of the wafer for 1s and had no pause at the edges. The brushing rotation speed of the wafer was 400 rpm. The brush moved back and forth for 5 times for brushing. Then, an 8-second deionized water rinsing was conducted, followed by wafer spin-drying at a rotation speed of 3500 rpm for 26 seconds. With 768 wafers processed, 62 wafers sampled, and the number of particles $\geq 0.3 \mu\text{m}$ was is smaller than or equal to 113.

[049] Example 11

- (a) It was same as Example 2.
- (b) It was same as Example 2.
- (c) It was same as Example 4.
- (d) It was same as Example 5.
- (e) The polished surface of the lithium niobate wafer was subjected to brushing process by single-sided brush, with simultaneous dual-fluid spraying performed during brushing. When brushing, the distance of downward pressing of the brush was 1000 μm , the brush rotation speed was 1300 rpm, and a translational speed of the brush was 17 mm/s. The brush paused at the center of the wafer for 1s. The brush paused at the edges of the wafer for 3s. The brushing rotation speed of the wafer was 400 rpm. The brush moved back and forth for 5 times for brushing. Then, an 8-second deionized water rinsing was conducted, followed by wafer spin-drying at a rotation speed of 3500 rpm for 26 seconds. With 960 wafers processed, 77 wafers sampled, and the number of particles $\geq 0.3 \mu\text{m}$ was is smaller than or equal to 27.

[050] Example 12

- (a) It was same as Example 2.
- (b) It was same as Example 2.
- (c) It was same as Example 4.
- (d) It was same as Example 5.

(e) The polished surface of the lithium niobate wafer was subjected to brushing process by single-sided brush, with simultaneous dual-fluid spraying performed during brushing. When brushing, the distance of downward pressing of the brush was 1000 μm , the brush rotation speed was 1300 rpm, and a translational speed of the brush was 17 mm/s. The brush paused at the center of the wafer for 1s. The brush paused at the edges of the wafer for 5s. The brushing rotation speed of the wafer was 400 rpm. The brush moved back and forth for 5 times for brushing. Then, an 8-second deionized water rinsing was conducted, followed by wafer spin-drying at a rotation speed of 3500 rpm for 26 seconds. With 944 wafers processed, 76 wafers sampled, and the number of particles $\geq 0.3 \mu\text{m}$ was is smaller than or equal to 26.

[051] Comparing Examples 8, 10, 11, and 12, as shown in Table 4 and FIG. 5, during brushing, when the brush pauses at the edge of the wafer for 3s or more, a higher level of cleanliness is achieved, which effectively removes particles that have accumulated at the edge of the wafer during brushing from the inside of the wafer towards the outer side.

[052] Table 4 Granularity of Wafer Subjected to Single-Sided Brushing in Examples 8, 10, 11, and 12

Test Item	Example 8	Example 10	Example 11	Example 12
particles $\geq 0.3\mu\text{m}$	≤ 47	≤ 113	≤ 27	≤ 26

[053] Although embodiments of the present disclosure have been illustrated and described, it is understood that those ordinarily skilled in the art can make various changes, modifications, substitutions, and variations to these embodiments without departing from the principles and spirit of the present disclosure. The scope of the present disclosure is defined by the appended claims and their equivalents.

What is claimed is:

1. A method for cleaning lithium-niobate single-sided polished wafer, wherein the method comprises following steps:

(a) soaking the lithium-niobate single-side polished wafer in an ammonium hydrogen fluoride dilution solution to remove a residual silica polishing slurry from a surface of a polished wafer, and then rinsing the wafer in a pure water;

(b) preheating and soaking the wafer treated in step (a) in a pure water at 55-65 °C for 1-3 minutes; and then placing the wafer in an organic solvent cleaning solution at 70-80 °C for an ultrasonic cleaning for 10-20 minutes to remove a contamination from the surface of the wafer;

(c) using deionized water to repetitively perform a spraying, a water injection, an overflowing, and a fast-draining on the wafer treated in step (b) to remove micro-particle impurities and a residual cleaning solution on the surface of the wafer;

(d) brushing the wafer treated in step (c) with a dual-sided brush in an alkaline cleaning solution, and then conducting a brushing with the dual-sided brush and a spraying rinsing in a deionized water; and performing a spin-drying process, wherein the alkaline cleaning solution is prepared by mixing the deionized water and an alkaline cleaning agent in a volume ratio of 30-50: 1; and

(e) attaching a backside of the wafer treated in step (d) to a vacuum platform; conducting a brushing by a single-sided brush with a polished side facing up, wherein a distance of downward pressing of the brush is 900-1200 μm , the brush rotates and translates on the surface of the wafer, and pauses for 3-5s when the brush reaches an edge of the wafer; and simultaneously conducting a two-fluid spraying during the brushing, and then rinsing with the deionized water and carrying out a spin-drying process to make the number of particles not less than 0.3 μm on the surface of the wafer not exceed 30.

2. The method for cleaning lithium-niobate single-sided polished wafer according to claim 1, wherein in the step (a), the lithium-niobate single-side polished wafer is soaked in the ammonium hydrogen fluoride dilution solution at a temperature of 30-40 °C with a soaking time of 10-30 minutes; and the wafer is rinsed in the pure water at a temperature of 30-40 °C for 3-5 minutes.

3. The method for cleaning lithium-niobate single-sided polished wafer according to claim 1, wherein a mass fraction of ammonium hydrogen fluoride is 98% in the step (a), and the ammonium hydrogen fluoride dilution solution is prepared by mixing the pure water and the ammonium hydrogen fluoride in a mass ratio of 10-15: 1.

4. The method for cleaning lithium-niobate single-sided polished wafer according to claim 1, wherein an ultrasonic frequency is 40 kHz, in the step (b), the organic solvent cleaning solution is prepared by mixing the pure

water and an organic solvent cleaning agent in a volume ratio of 5-10: 1, and a mass ratio of each of components in the organic solvent cleaning agent is isopropanolamine 15-20%, N-methylpyrrolidone 30-40%, potassium hydroxide 3-10%, and the pure water 40-60%.

5.The method for cleaning lithium-niobate single-sided polished wafer according to claim 1, wherein a spraying time in the step (c) is 50-70s, a water injection volume submerges the wafer, an overflowing time is 20-30s, and a fast-draining time is 10s; and processes of the spraying, the water injection, the overflowing, and the fast-draining are repeated 4-6 times.

6.The method for cleaning lithium-niobate single-sided polished wafer according to claim 1, wherein a dual-sided brushing in the step (d) employs a method using a dual-sided transmission rolling brush, wherein the brush rotates and moves the wafer in a translational motion; the brush used for the dual-sided brushing is a roller brush made of PVA; and a brush rotation speed is 6-10 rpm, a pressing distance of upper and lower brushes is 1000-1300 μm , a brushing time is 3-5 minutes, a brush diameter is 2-3 cm, a spraying rinsing time is 10-20s, a rotation speed for a wafer spin-drying is 1200-1500 rpm, and a time of spin-drying is 15-20s.

7.The method for cleaning lithium-niobate single-sided polished wafer according to claim 1, wherein in the step (d), a mass ratio of each of components in the alkaline cleaning agent is sodium hydroxide 0.2-0.6%, potassium hydroxide 1-3%, a chelating agent 0.5-2%, a non-ionic surfactant 2-5%, and the deionized water 90-96%.

8.The method for cleaning lithium-niobate single-sided polished wafer according to claim 1, wherein in the step (e), the brush used for a single-sided brushing is a gyroscope-type brush made of PVA; a distance of downward pressing of the brush ranges from 900 to 1200 μm ; a rotation speed of the brush is 1000-1500 rpm; a translational speed of the brush is 15-20 mm/s; the brush pauses at a center of the wafer for 0.5-1s; the brush pauses at edges of the wafer for 3-5s; a brushing rotation speed of the wafer is 300-600 rpm; the brush moves back and forth 3-5 times for the brushing; the rinsing with the deionized water takes 5-10s; a rotation speed for a wafer spin-drying is 3000-4000 rpm; and a time of spin-drying is 25-30s.