Usefulness of the ultra-compact deionized water recycling unit for dicing saws

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Abstract

Ultrapure water is used for cooling and cleaning in the semiconductor manufacturing industry. Thus, semiconductor manufacturing factories generally install large deionized water manufacturing, drain recycling, and liquid waste disposal facilities. However, because they are large facilities, there are issues in flexibility, such as downtime for the entire plant due to regular maintenance or minor improvements. In this review, we introduce DWR1722, an ultra-compact deionized water recycling unit for dicing saws, which is small but realizes a high deionized water recycling rate with low electric power consumption.

1. Introduction

A dicing saw (dicer), which cuts silicon wafers during the semiconductor manufacturing process, uses deionized water (DI water) for cooling and cleaning. In recent years, the consumption of DI water has increased in order to clean the wafers more thoroughly, and the effective use of water resources is critical in order to reduce environmental impact. Because of this, the amount of DI water consumed by dicers needs to be reduced, which can be accomplished by recycling the water discharged. However, the conventional DI water production and recycling systems are generally large and expensive because they have to cover the entire water systems of the factories. Thus, the operations of the factory must be completely shut down for periodic maintenance of the recycling unit; moreover, it is not easy to enhance the capacity of the recycling unit on a small scale.

Therefore, we developed the DWR1722, an ultracompact DI water recycling unit for dicers capable of extraordinary energy and water conservation (Photo 1).

Photo.1 DWR1722

2. Problems of the conventional DI water recycling units and their solutions

Recycling of wastewater from the dicer as cutting water requires the following functions:

(A) Removal of solids, such as silicon fragments, using a highly efficient filter

(B) Sterilization and organic matter decomposition using a UV lamp

(C) Ion removal using an ion exchange resin

(D) Water temperature adjustment using a refrigerator and a heater

As shown in Fig. 1, particle sizes of silicon fragments contained in the wastewater drained from the dicer are normally below 0.5 μm. Thus, an extremely fine mesh is required by the filter to

implement function (A). Filtration systems employed in the conventional DI water recycling units use filters made of expensive materials, such as ceramics and organic membranes, and their structures are complex and large.

In addition, more space is required in order to implement functions (B), (C), and (D) using the recycling system, which makes it difficult to design a compact unit that can be installed adjacent to the dicer in the clean room.

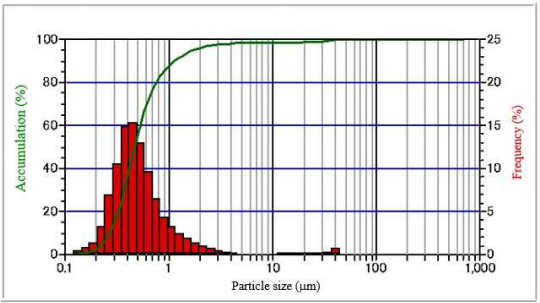

Fig. 1 Particle sizes of silicon fragments contained in the wastewater from the dicer.

Because of these reasons, the conventional DI water recycling units are usually large and installed outside the clean rooms. This makes it necessary to secure the installation space and pay the extra cost of DI water supply and drain piping work from the dicer to the DI water recycling unit. Further, expenses are incurred in the treatment of concentrated wastewater.

We solved these problems and realized a DI water recycling unit DWR1722 that can be installed adjacent to the dicer in the clean room. The development of this recycling unit focused on the following points:

1) Ultracompact design
2) Zero wastewater
3) Low power consumption
4) Easy maintenance and operation

2.1 Ultracompact design

Simplifying the structure is essential to downsize the recycling unit. The filtration method that uses the ceramic filter or organic membrane mentioned above is called cross-flow filtration but the dead-end filtration method is also available (Fig. 2). Cross-flow filtration is a system that filtrates while cleaning the membrane with the power of flowing raw water. Then, other systems, such as backwash, are combined with it to reduce the clogging of filter. This reduces the frequency with which filter needs replacement, but it makes the system's structure larger and more complex. It is also necessary to pass more raw water than filtrated water, and therefore, a larger pump is required. Further, silicon fragments caught by the filter are discharged as concentrated wastewater. It is also necessary to install a tank that stores this wastewater. On the other hand, in dead-end filtration, fragments accumulate on the filter surface, which deteriorates its filtration ability. Therefore, it is necessary to replace the filter periodically. However, since this method does not require other systems, it is the simplest filtration method.

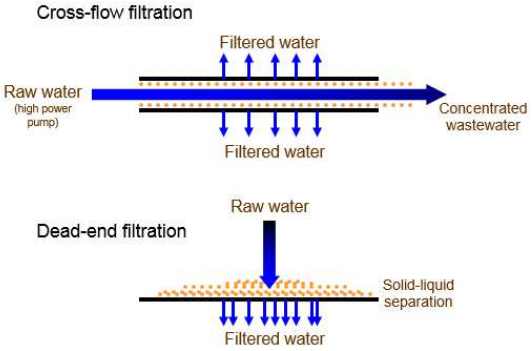

Fig. 2 Cross-flow filtration and dead-end

For these reasons, the DWR1722 employs the dead-end filtration, which enables downsizing. However, the filters currently available in the market are not practical because their lifespans are extremely short. Thus, we have developed "CC Filter" (Photo 2), an original filter dedicated to the filtration of drain water from the dicers. CC Filter is a disposable filter module having its own unique structure. With this filter, all the functions from (A) to (D) can be installed in the DI water recycling unit with a very small footprint.

Photo.2 CC Filter

2.2 Zero wastewater

The recycling rate of conventional DI water recycling units is generally from 80 to 95%. Concentrated wastewater that is not recycled requires further treatment and has to be disposed of as industrial waste with charge. When hazardous materials such as gallium arsenide (GaAs) are diced, the treatment of wastewater is particularly difficult and expensive. Thus, if 100% recycling rate and zero wastewater can be realized, it eliminates the need for a wastewater treatment system, which provides a great advantage.

The DWR1722 uses the CC Filter of the dead-end filtration system, thereby achieving zero concentrated wastewater. One CC Filter enables the capture of silicon fragments discharged from one dicer for a month. The captured silicon fragments can be disposed of as solids together with the CC Filter.

Wastewater filtered through the CC Filter becomes colorless and transparent pure water. However, in order to recycle it to DI water, it is further necessary to remove ion components and organic matters dissolved in the wastewater.

The ion components can be removed through an ion exchange resin, but not the organic matter. The wastewater from the dicer contains a large quantity of organic substances originating from the dicing materials like dicing tapes. Therefore, if this water is recycled, the concentration of organic matter increases, which may have a negative impact on the bonding process after dicing and quality of devices. Thus, an ultraviolet (UV) lamp module specifically designed for the DWR1722 is installed, which enables efficient dissolving of organic matter contained in dicer wastewater. With this UV lamp module, wastewater is irradiated by UV beams having wavelengths of 254 nm and 185 nm before filtering the wastewater through the ion exchange resin to dissolve organic matter into an organic-acid level. As a result, recycling rate of 100%[Note 1] and zero wastewater can be achieved.

2.3 Low power consumption

By using the CC Filter of the dead-end filtration system, power required by the filtration pump can be minimized. Further, the system for cooling the water uses the waste heat of the refrigerator instead of the conventional heater proportional-integral-derivative (PID) control scheme. This is particularly helpful in reducing the power needed for temperature control. The temperature control system of the DWR1722 installed adjacent to the dicer is much simpler because wastewater can be directly controlled from the processing point of the dicer. Because of the optimized design of each section, the DWR1722 is capable of processing wastewater from two dicers, but the power consumed is half to one-third of that consumed by the DTU152, which controls only water temperature.

2.4 Easy maintenance and operation

The DWR1722 is developed to be installed adjacent to the dicer in the clean room and to be used in conjunction with it. Thus, the same maintenance personnel that perform the maintenance work of the dicer can maintain the recycling unit as well. In order to enhance user friendliness, a large color touch panel is used for operation. Screen configurations are designed such that the structure of the unit can be recognized intuitively. To facilitate the replacement of the CC Filter and ion exchange resin, they have a slide-out structure for easy maintenance in a compact design.

3. Conclusion

The DWR1722 is a DI water recycling unit with excellent features, such as ultracompactness, zero wastewater, low power consumption, and easy maintenance and operation, designed to be used with dicers. The recycling of DI water is also demanded by other equipment, such as grinders. With the help of results from various applications, we plan to develop other recycling units that are compatible with different types of equipment. We intend to undertake further efforts to preserve the global ecosystem and natural environment through the realization of resource conservation and zero emission.

Note

1. More precisely, the maximum recycling rate is approximately 99.5% because around 0.5% of the wastewater vaporizes during dicing.

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