Diagnosis of D-line Cutting by Process-Oriented Environment Investigation

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ABSTRACT

A severe D-line cutting defect with different kinds of mode happened to the array substrate prevalently. An environment survey based on process-oriented approach was developed to locate the cause. The investigation shows the potential cause is due to cross contamination between different processes.

INTRODUCTION

A G5 TFT FAB had have troubles with D-line cutting defect for a long time. The popular mode of defects is the D-line with some small bites as shown in Fig 1.

To fix this trouble, a series of evidence and experiment was done and collected and most important, a process-oriented environment investigation approach was developed to clearly identify the possible cause for such a defect.

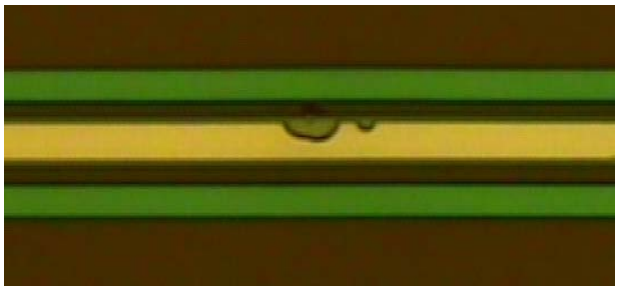

Fig. 1. Defect photo of D-line cutting.

INVESTIGATION OF ENVIRONMENTAL ASPECT

Environment Air Sampling

A basic environment investigation was conducted by air sampling for organic and inorganic gases. The Tenax-GR is used for organic sampling and impinger bottles filled with DI water are used for sampling of water-soluble gases, like SO_2, HNO_2, HNO_3, HCl, HF, NH_3, and MEA.

MEA was used by stripper process before and they did not use it any more at the time of sampling for a half year already. The chemical used for photoresist stripping now is NMP.

Equilibrium Test of Used Filters

Fortunately, we got three pieces of used ULPA filters from different three stockers. It would be an interesting work to understand the contents already accumulated on filters.

For understanding the status of these used filters, we designed a test station with controllable air volume of recirculation and fresh air for full size ULPA measurement[1].

The concept of the test station is to give ULPA enough time to reach an equilibrium between air and filter media so that we could identify the possible outgassing chemicals of contents accumulated on the surface of filter media. The result showed something comes out from the used filters and the amounts are different corresponding to different stockers as Fig 2.

It is clear the closer to STK04, the higher the concentration of MEA is. And another interesting finding is STK02 is the closest to Wet Etch process zone than the other two so the acetic acid got the highest concentration because acetic acid is one of the major chemicals used by Wet Etch zone. This indicates high accumulation amount of acetic acid on the filter surface in the past utilization.

Based on the above idea, we can say due to air flow characteristics and the potential chemical spreading effect, the closer to STK04, the more amount accumulation of MEA might be.

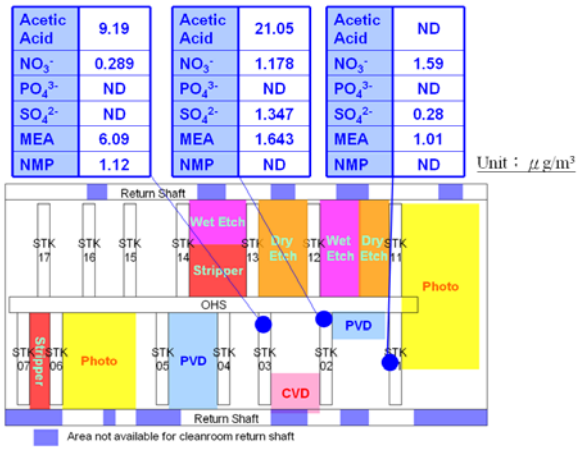

Fig. 2. Result of equilibrium test of used filters.

Review of Cleanroom Air Flow Pattern

To explain the above equilibrium test result, it is necessary to study the cleanroom air flow pattern, especially how clean air supplied from and how dirty used air gone back. The route of circulation

air gives us an image about how air mixing happens between different process zones.

The main factor to affect the air flow pattern in cleanroom is the available return shaft layout. This is a normal situation that some space of return shaft should be reserved for lifters, ladders, ducting/cabling, and tool move-in so the air route sometimes is not as what we imagine. Such an uneven blockage of return shaft will result in cleanroom air mixing from different process zones. The cleanroom air mixing and chemical spreading could be found in details as red arrows and air sampling result shown in Fig 3.

For example, the stripper area in between STK13/14 cannot get good air return due to some block as shown in blue color so the air full of stripper would be expelled to STK4 and 3. And this is the reason why STK3 has higher concentration of MEA and NMP than the other two stockers.

If we check the cleanroom air sampling data, it is reasonable to find higher concentration of MEA in stripper area. However, you can also find the neighboring area of stripper also has higher concentration due to return air path as shown in red arrows in Fig3.

Another interesting finding in Fig 3 is even MEA is never used for a half year but it still can be found in the air.

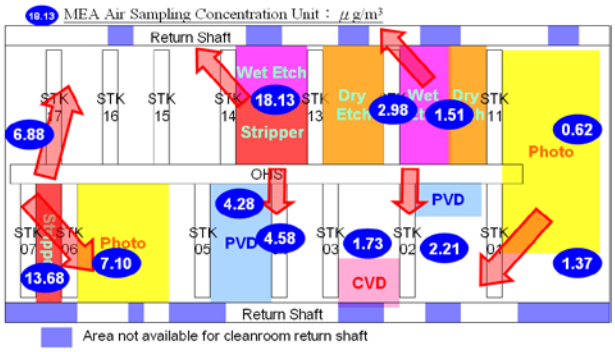

Fig. 3. Cleanroom air concentration and flow pattern.

Dissolving Test of Cooling Coil Fins

All circulation air would pass through cooling coil. So we could get some hints from the analysis of fins of coil. We tried to get the fins from different zones as shown in Fig 4.

A DI water dissolving procedure was conducted to extract the possible chemicals on the surface of fins. The result is as shown in Fig 4. The result also shows some residuals of MEA on the surface of fins and the distribution of concentration is also reasonable.

The higher accumulation of MEA could be found in zone 1 which is closer to stripper area. And the result tells us MEA could be stick on the surface for a long time even it is not used for more than a half year.

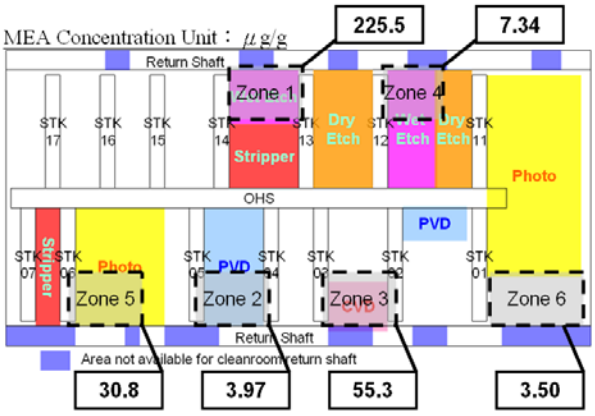

Fig. 4. Result of dissolving test of cooling coil fins.

INVESTIGATION OF PROCESS ASPECT

Possible Cause of D-line Cutting

The cause to induce such a defect may mostly attribute to bad photoresist adhesion with its substrate. The bite shape is due to anisotropic wet etching as the mechanism shown in Fig 5.

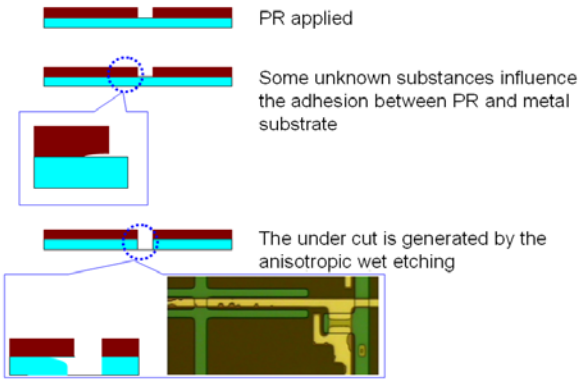

Fig. 5. Deduction of mechanism of D-line cutting.

Chemical Identification for Bad Photoresist Adhesion

The chemical can result in bad photoresist adhesion should be something against photoresist. The first one would be reminded is the chemicals used for photoresist stripping or developing.

Many kinds of chemicals might have such function, like MEA, DMSO, TMAH, NMP, PGMEA, etc.

After screening the air sampling result and compared the concentration with past other plants database[2], MEA was zeroed in as a suspected chemical.

Process-Oriented Concept

The so called process-oriented concept means we not only focus on the process station where we

got troubles but also we check in details about the upstream and downstream processes of that troubled station.

As previous review of cleanroom air flow pattern, we could further figure out severely contaminated by MEA spreading due to cleanroom air flow pattern as STK with red marked in Fig 6.

Because the STK is used as a temporary storage for substrate, the longer the substrate stays, the more amount of MEA will accumulate. The more MEA accumulates, the worse the adhesion between photoresist and substrate is.

Based on the above concept, the process flow of substrate is important for judgment because it tells us where the substrate would stay.

Let's imagine the following substrate trip in this FAB.

If the prior process of photoresist applying stays in the severely contaminated stocker by MEA, it means the substrate would accumulate more MEA if the staying time is long enough. Then a substrate with high accumulation of MEA goes to next process, photoresist applying, and as you can imagine, MEA is against to photoresist, so the adhesion between photoresist and substrate might be bad although some pre-cleaning might be executed before photoresist applying. And the next story is happening while this substrate sending to next wet etching as you can imagine.

Fig 6 shows the process flow during which the substrate suffers the D-line cutting defect and also shows the major STK would be stayed by substrate.

As found in Fig 6, the substrate unexpectedly almost stays in red marked STK while waiting for processed.

This means while the substrate stays in the stocker, it might accumulate much amount chemicals against photoresist adhesion like MEA.

Especially, prior to photoresist applying, the substrate comes from PVD process. That is, the substrate stays in STK05 and STK04, which are severely contaminated by MEA. And this explains why the small bites happen.

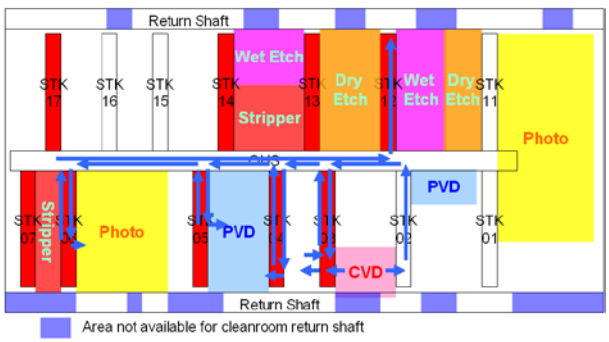

Fig. 6. Substrate processing route.

CONCLUSIONS

An environment sampling is a way always used while something wrong found in the process. However, it is still difficult to fix problem if just relying on the environment data.

However, if some cleanroom circulation engineering knowledge and process with from-and-to tracing could be incorporated with environment sampling data, sometime some finding might come out.

Here a combination aspect of environment investigation and process flow was developed and this is helpful for defect cause identification.

REFERENCES

1. C. I. Yang, W. T. Chiang and C. Y. Yang, IDMC2011, PS-68 (2011).
2. L&K air sampling database.