A Defect Defense Approach of Integrated Database Based on Over-Etched Defect

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Abstract
The aluminum line overetched defect might be called as undercut、PR Hole, etc by different manufacturers. The defect of this case study mainly shows a hole found on the aluminum line after stripper process but there is no any tracable symptom before the ending of dry etch process. That is, it seems no means to prevent or to found the root cause.

A defect defense approach via cleanroom air quality database based integrated with TFT manufacturing processes、air sampling、characteristics of manufacturing chemicals、cleanroom circulation and air flow pattern is proposed to demostrate how to figure out the root cause of aluminum line overetched defect, which found after stripper.

Via the aid of proposed approach, the analysis shows the defect arises from the cross contamination between photo、PVD and stripper process and the cross contamination comes from manufacturing layout、cleanroom circulation and air flow pattern.

Author Keywords
Overetched defect; cross contamination; AMC.

1. Introduction
It is prevalent defect that behaves as aluminum line overetched and is found after dry or wet etch process in FPD array manufacturing as a case study in this paper shown in Fig 1. Based on different description by different companies, this defect might be called as undercut、overetched、PR Hole, etc. However, actually all of them talk about the similar situation of defect or inspection results, that is, some of aluminum line is unintentional etched.

At the very beginning while such defect identified, it might be attributed to manufacturing skill or parameter setting. However, accompanying the accumulation of inspection and experiment by manufacturing engineers and more and more findings of unknown contaminants with brown color on cables or haze on transparent glass or panel, people start to doubt such defect might come from environment, especially from ambient air. And this is the reason why such a cleanroom professional engineering company could have chance to join the investigation of root cause of product manufacturing defect.

In order to realize what chemicals are contained in the air, an air sampling and analysis starts to be requested and emphasized by FPD manufacturers. However, there exists no such a popular guideline about the recommended or acceptable concentration level in FPD industry as that like ITRS Yield-Enhancement [1] in semiconductor industry. And then, another coming question is what is the meaning about those complicated chemicals and concentration level and how are those complicated chemicals and concentration level related to product defect?

In this study, a multi-disciplined and integrated approach will be introduced via a case study to show how to fix the overetched defect proposed by customers. And because of accumulated experience of this similar kind of defect, a potential risk analysis could also be defined. At final, this study ends as a view of cleanroom operation to explain how the contamination occurs. And the conclusion of prevention of cross contamination will be reached at the end.

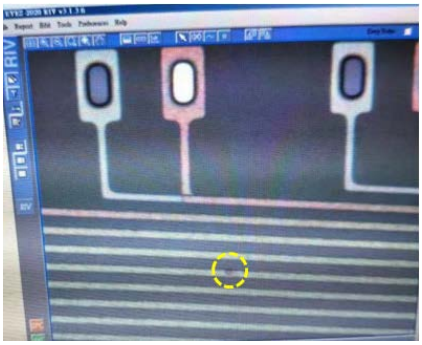

Figure 1. **Overetched defect.**

2. Cleanroom Air Quality Database
L&K engineering company devotes to provide the most suitable environment for customers. Although L&K engineering is an engineering company, company invested analysis instruments and chemical lab for chemical analysis and air sampling in the past ten years and have had practiced engineers to provide value-added service in his undertaken project. Via long term data accumulation, L&K engineering already collected more than 60000 set of air quality data in different industrial plants and classified data based on different processes.

Because of enough data quantity and detailed data classification at the beginning, what L&K engineering owns now could make statistics or comparison based on different companies, different stage(such as, pilot run, mass production), different industrial area(such as, array, CF, Cell, LTPS, Touch Panel, IC, Packaging, Solar Cell,…,etc), different chemicals, and different locations(such as, outdoor, ploto, PVD, CVD, dry etch, …,etc) based on the target of analysis requirement.

In this case study, the data of PVD area for whole array FABs at mass production stage is filtered and the specific chemical species are selected based on the analysis of manufacturing processes, manufacturing chemicals and defect characteristics.

3. Review of Relationship between Defect and Manufacturing Processes and Chemicals
At first, let's simply describe the overetched defect of this study.

The defect is found after dry etch but there is no any abnormal pattern after photo line inspection. However, such kind of defect occurs at the location where the aluminum line is already protected by PR at normal manner. But even so, the defect is still located. A possible way to explain such phenomena is a

hole created at the moment while vacuum goes up so that the following etchants eat the aluminum line that should be remained there based on design pattern as the mechanism shown in Fig 2. It is doubt that there something unknown deposits on the aluminum surface before PR coating of photo line process and weakens the adhesion or strength of PR so that the film of PR cannot sustain the pressure difference created by dry etch chamber environment.

The chemicals have features to dissolve, weaken PR and also used in process of this study could be identified as additives of PR or stripper for PR removal. In this study, PGMEA, PGME and benzyl alcohol are the additives as solvent in PR and DMSO, MEA and NMP are already well known stripping chemicals for PR stripper.

In order to suspension in the air, the above chemicals need other assistants to form a tiny droplet. Benzaldehyde, ethanol and THC are selected as such major roles in this study based on the past similar experience.

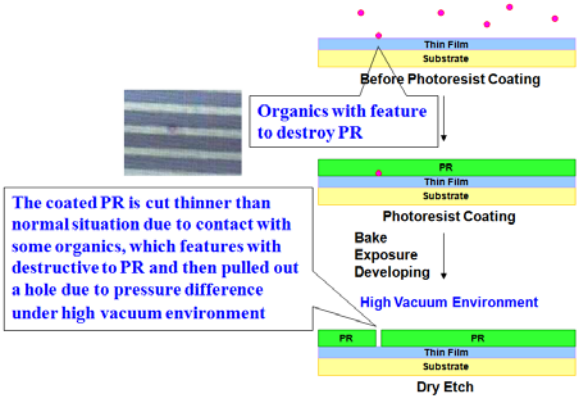

Figure 2. **Mechanism of formation of overetched defect.**

4. Air Sampling and Site Survey

Based on the analysis of defect and manufacturing process and chemicals, two kinds of air sampling methods were used. One is impinger, an in series of bottles filled with DI water, for MEA collection and analyzed by ion chromatography as shown in Fig 3(a). Another one is tenax tube, a tube filled with special adsorbent, for organics collection and analyzed by gas chromatography in series with mass spectrum as shown in Fig 3(b).

While sampling, it was found the product with PR hole will go through the scanner as in Fig 4 with the feature that stripper, wet etch and photo line(track and scanner) share the same return shaft.

The layout as shown in Fig 4 is a standard example with cross contamination of stripper/wet etch and photo line.

(a) (b)

Figure 3. **Sampling and analysis instrument.**

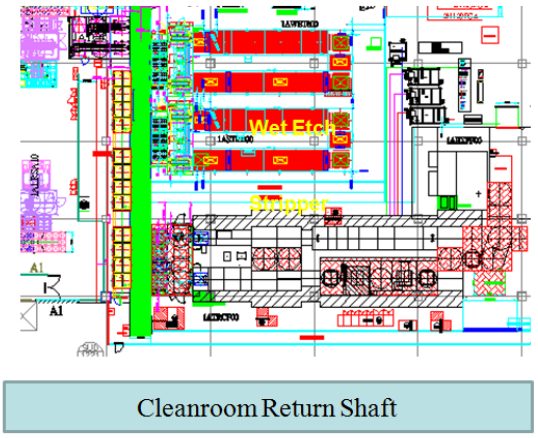

Figure 4. **Site survey and tool layout.**

5. Integrated Analysis Based on Database

The integrated database-based analysis is described as a radar diagram as in Fig 5 for this case study.

The selected chemicals are put around the perimeter and the concentration level studied case is ranked as a percentage compared to the database collected by L&K engineering in the past 10 years. Each ranked point of chemical is connected by red line in Fig 5.

The meaning of ranking represents the closer to 100% the closer to the highest level of concentration of L&K database. Because of log-normal distribution characteristics, a reasonable average or median value is located at about 20%. As shown in Fig 5, DMSO and MEA behave as high concentration level compared to L&K database and this just provide evidence for the assumption of mechanism in Fig 2.

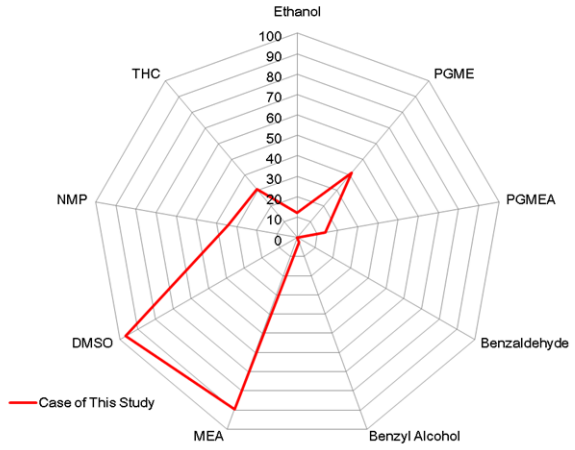

Figure 5. Integrated a**nalysis diagram of this study**

6. Comparison of Reference Plants

Only the evidence of Fig 5 is not enough to confirm the assumption in Fig2.

However, there are two another studies for further comparison as shown in Fig 6.

As shown in Fig 6, the green dashed line represents similar defect and blue dashed line without such defect. It is very easy to find the similarity between red line (this study) and green dashed line (referenced FAB). They are different companies but their panel size is G5.

Another interesting way to treat this radar diagram is the area enclosed by each line might be used as a way to talking about the strength of occurrence of overetched defect. If the red line represents 100% possibility and then the blue line might be about 47% based on the area ratio. Such information could provide customer a feeling to make decision for further prevention action.

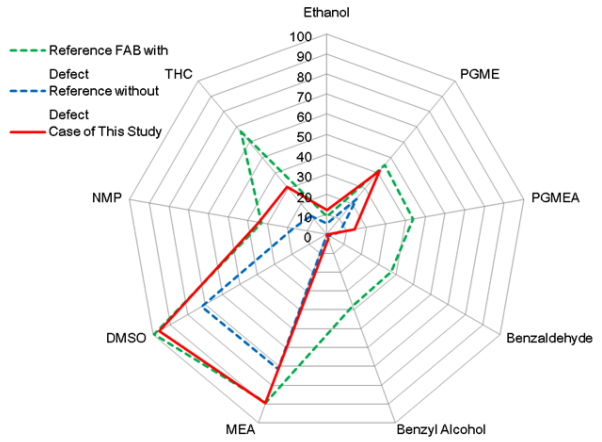

Figure 6. Comparison of integrated a**nalysis diagram** for different FABs

7. Discussion on the Cross Contamination - Contaminant Transportation

A view from overall cleanroom and product manufacturing operation to explain the occurrence of mechanism of overetched defect could be found in hypothesis of Fig 7[2][3].

The hypothesis tries to describe how cross contamination goes through the whole manufacturing processes.

The cleanroom air content is contributed by two sources, one comes from outdoor air (except some specific defect, this is not the major cause and this may come from the process exhaust system) and another one is the leakage or release of process tools. The concentration level determines the cleanroom air quality.

The concentration level of different chemicals might be different due to the usage by the process. While leakage occurs, the chemicals would be spread by cleanroom air circulation, mixing and exchanging, if tool layout and cleanroom isolation are not integrated designed and arranged.

The chemicals spreading inside cleanroom at different area with different concentration level, contact with different product surface, and different contact duration time result in different device film surface characteristics. They might be corrosion, adding unintentional doping or modification of surface adherence character. Finally the defect occurs at "process N" (dry etch in this study) and reflects specific phenomena (aluminum line unintentional etched) but the cause might already be planted before "process N" via the cleanroom air motion.

For such a way that the chemicals origin from "process K" (stripper as major source in this study) and the chemicals spread to other processes with lower concentration level than that of original location and deposit on the product surface in "process L" (PVD and route before PR coating) and finally result in defect in "process N", it is called as cross contamination.

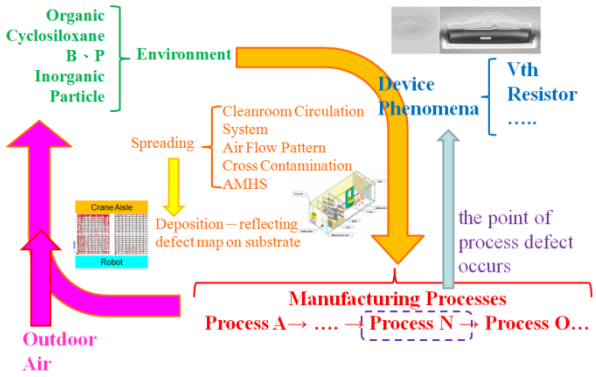

Figure 7. **Hypothesis of relation between defect and environment.**

8. Conclusions

A way multi-disciplined and integrated with manufacturing processes、air sampling、characteristics of manufacturing chemicals、cleanroom circulation and air flow pattern is proposed to fix a prevalent defect, overetched, in FPD array FAB.. And two referenced data is provided for further comparison. The integrated analysis diagram could also provides potential risk analysis, especially while enough data accumulated.

Finally, the major cause could be attributed to cross contamination inside the whole cleanroom due to clean air circulation, mixing, and exchanging. It is recommended an in-time cooperation design between tool layout and cleanroom isolation at the very beginning of project so that an effective control could be planned at an economical and feasible way.

9. Acknowledgements

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10. References

[1] ITRS-2.0-Yield-Enhancement (2015)

[2] Cheng Yu Yang, "On the State of Art and Future Trend of Clean Technology on FPD Industry," International optoelectronics and displays, 10,(2014)

[3] Cheng Yu Yang, "Review of Device Defect Related to Environment Contamination in FPD Manufacturing" , ICDT 2018