Review of Applications of Environmental Assessment on Defect Defense in FPD Industry

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Abstract

As the feature of product size of FPD industry, the dimension of product in processing is larger relative to semiconductor industry, especially for the coming of new generation. This characterizes large chemical usage (potential chemical leakage), factory footprint (high recirculation air flow volume and complex air exchange possibility), and transportation vehicle (high air resistance and unintentional air transfer) and makes the AMC issue on product devices largely different from that of semiconductor industry.

Based on past more than 15 years of work experience accumulation, an aided way integrated with air sampling and database analysis, CFD (computational fluid dynamics, tool layout and process flow, and cleanroom circulation investigation as a name "environmental assessment" has gradually gained recognition and acceptance for defect defense in FPD industry applications.

This review introduces how the environment is systematically assessed and share how these four approaches work on assessment by past work defense.

Author Keywords

environmental assessment, air sampling and database analysis, CFD, tool layout and process flow, cleanroom circulation, AMC.

1. Introduction

As the mature manufacturing technology, it seems AMC is becoming more and more attractive issue in FPD industry yield rate breakthrough although AMC stems from semiconductor industry. As the feature of product size of FPD industry, the dimension of product in processing is larger relative to semiconductor industry, especially for the coming of new generation. This characterizes large chemical usage (potential chemical leakage), factory footprint (high recirculation air flow volume and complex air exchange possibility), and transportation vehicle (high air resistance and unintentional air transfer) as shown in Fig 1. These characteristics make the AMC issue of FPD industry highly different from that of semiconductor industry.

Based on past more than 15 years of work experience accumulation as the defect classification in Fig 2 [1], the more defect issue we coped with and the clearer picture about how to approach the defect defense work is converged.

The picture we found is a systematic integration as a name "environmental assessment" with the hybrid applications of different fields of technique as air sampling and database analysis, CFD (computational fluid dynamics, tool layout and process flow, and cleanroom circulation investigation.

This review will introduce how the environment is systematically assessed and share how these four approaches work on assessment by past work defense.

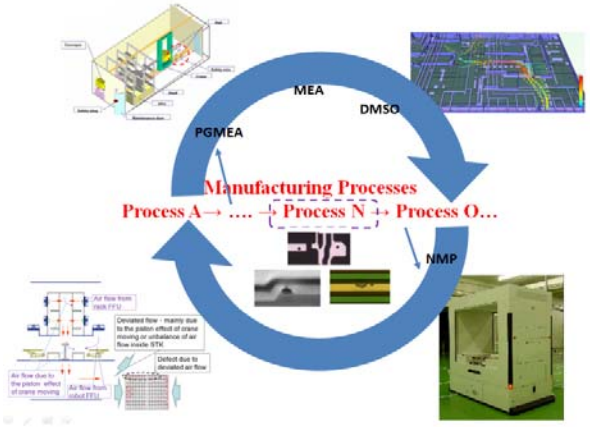

Figure 1. **Feature of FPD AMC Issue.**

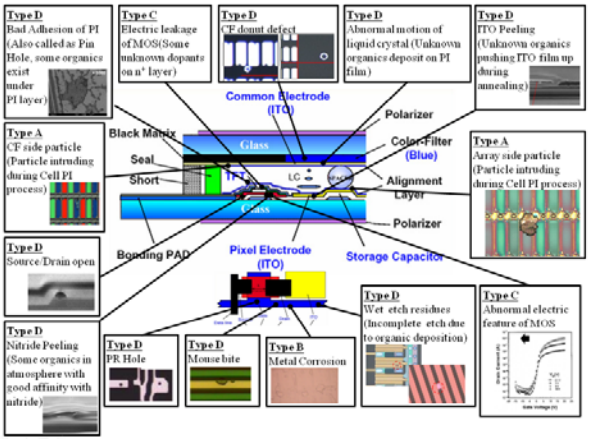

Figure 2. **Classification of defect of TFT/LCD panel.**

2. Air Sampling and Database Analysis

The air sampling technique is already a mature and prevalent application tool in FPD industry. The impinger is used for inorganic gases and MEA (some companies use this chemical) and the sample is analyzed by ion chromatography. The tenax tube is used for organic gases and analyzed by gas chromatography and mass spectrum as shown in Fig 3(a)(b).

When enough concentration data set (more 100) at the same process station and chemical but at different timing and companies is collected, a statistics could be performed and find something interesting as shown in Fig 3(c)(d).

The statistic distribution behaves as in Fig 3(c) and the sequence or ranking could be gained by integral of distribution curve as in Fig 3(d). The meaning of ranking could give you a feeling of

how small or how large of your FAB concentration is if your data is put into this ranking. Because the statistics is made from many different companies, this ranking will show you how contamination severity of your FAB is. In past application experience, even the distribution curve as Fig 3 (c) is quite good enough to convince customers to believe how bad his cleanroom environment is [2].

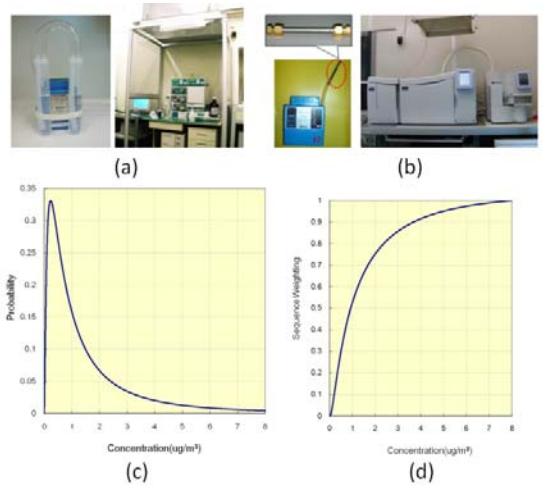

Figure 3. **Air sampling and database analysis.**

(a) Impinger and ion chromatography

(b) Tenax tube and gas chromatography with mas spectrum

(c) Statistics of sampling data of probability distribution

(d) Statistics of sampling data of ranking

3. CFD

CFD is the abbreviation of computational fluid dynamics and it is a very useful tool for the applications of flow and contamination control in cleanroom. At the age of now, any investment in FPD industry, even a relayout cleanroom construction, costs lots of money. It is impossible to execute any new idea without any evaluation and CFD is such a tool to provide low cost but valuable evaluation.

You can easily create a similar computer cleanroom model as you will use in the future like Fig 4 (a) shown. In Fig 4(a), a G5 TFT FAB with AGV transportation system, it is easily to explain why zone A in Fig 4(b) will find the chemical NMP, even no usage there, via the inspection of flow stream in Fig 4 (b). This is a good example to show how CFD is helpful to identify the potential issue inside cleanroom.

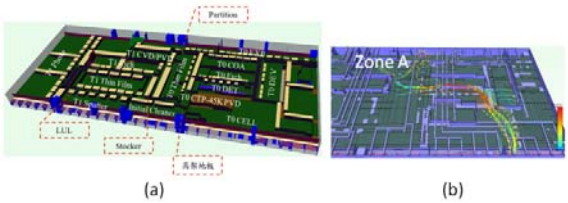

Figure 4. **CFD modeling and applications.**

(a) CFD model of a G5 TFT FAB

(b) Air stream of right portion of model (a)

4. Tool Layout and Process Flow

The tool layout here includes not only the production equipments but also the transportation system. Transportation system normally play a role to spread process chemicals from one area to another under the interaction with cleanroom circulation.

Process flow shows the processing from-and-to of different layers on device. In order to fix the defect issue, it is necessary to trace back from the process station where defect is found to the previous processes and to inspect the place transportation vehicle passes based on the understanding of from-and-to of manufacturing process. Based on past experiences [1], the place where defect announces normally is not the right place of root cause located. During the activity of such a trace-back survey including transportation route and temporary storage location [3], the suspected process station and chemicals could be identified. According to the survey result, the air sampling location could be effectively confirmed and the database analysis with ranking could be applied as a radar diagram shown in Fig 5.

Each ranking of chemical, which indicates how high or how low the concentration level of suspected process station is if compared with other companies' data, shows you the possibility to induce the defect issue. As the result found in [4], the area enclosed by red line in Fig 5 could become as another indicator if referenced similar defect problems accumulate enough data and experience.

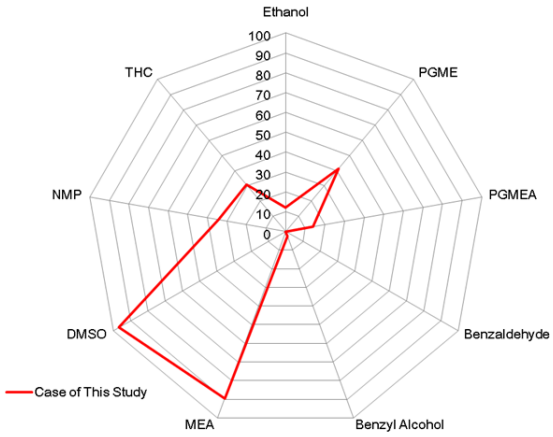

Figure 5. **Sampling data analysis as a radar diagram.**

5. Cleanroom Circulation Investigation

The reason to investigate the cleanroom circulation is also important is because the way air flows inside cleanroom sometime deviates what you imagine. It is highly related to tool, partition and cleanliness layout. An evident example could be found in Fig 4(b). The place air travels to is far away what you can imagine.

Another case is an Al line corrosion issue [5]. There are nine sets of dry etch tool in parallel located in front of return shaft. The strange phenomenon is the Al line corrosion just happens on the Load/Unload of one of the dry etch tool as Fig6 with light blue color of cloud area. The CFD calculation result was correctly verified with site inspection. In this real case study,

the cleanroom air returns from return shaft might not go straight as what we imagine.

The purpose of cleanroom circulation investigation is to get an overall view about the transferring, mixing, and spreading of chemicals so that it would be helpful to select and determine the best location of sampling point and to analyze the sampling result from the standpoint of cleanroom operation.

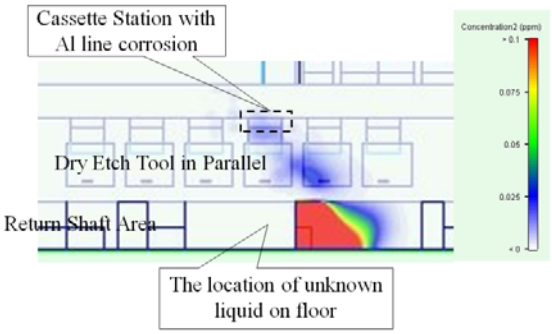

Figure 6. **Example of Al line corrosion.**

6. Environmental Assessment

As reviewed in previous paragraph, the environmental assessment is composed of four different fields, air sampling and database analysis, CFD, tool layout and process flow, and cleanroom circulation. This systematical integration of four fields is gradually developed in past 15 years for different kinds of defect problems until the radar presentation developed as the evolution and changes of thinking route in [2][3][4].

The standard working procedure of environmental assessment is as follows,

(1) Starting from the clarification of defect issue including FIB and EDS result.

(2) And then the process station of manufacturing from-and-to is reviewed and discussed with production engineer of customer.

(3) The possible defect mechanism reaches common agreement with production engineer of customer and the target chemicals are identified.

(4) Based on the target chemicals and process chemical usage information, the air sampling points are determined accompanying with the concerning of cleanroom circulation route and cassette transportation effects. If something difficult to judge the air spreading route, CFD might be helpful to provide good suggestions.

(5) The sampling and analysis method of some special chemical should be reviewed to make sure successful gathering of contaminant such as TMAH, MEA, etc.

(6) Executing air sampling and chemical analysis.

(7) Ranking the concentration level with database and creating radar graph according to the selected chemicals.

(8) Judging the meaning of radar graph and discussing the root cause. Sometimes CFD might be used to verify the result if argue or doubt occurs.

(9) To effectively fix defect issue, a refurbishment or modification of cleanroom might be required. It is strongly recommended to use CFD to assist feasible evaluation.

Based on past 5 years application experience, something might be changed or modified while performing the above procedures. However, the more detailed defect information and process from-and-to provides, the more satisfied conclusion reaches.

7. Conclusions

The AMC induced defect issue in FPD industry is essentially different from that in semiconductor industry.

The FAB operation and environment AMC control just requires an economical and acceptable level concentration in FPD industry rather than that to reach an absolutely low level concentration in semiconductor industry. Such a difference makes totally different AMC control approach and thinking route.

Because of no absolutely low level specifications to follow in FPD industry, a benchmarking of database analysis with ranking grade is easy and intuitive to provide another standpoint about defect if suitable combinations with tool layout and process flow, cleanroom circulation and aids of CFD.

It already successfully proves the feasibility of the concept of integrated environmental assessment in past 5 years applications in FABs at Shanghai, Shenzhen, Wuhan, Linkou, Bade, Zhunan, and Tainan for different kinds of defect problems to assist customers to clarify and fix their troubles..

8. Acknowledgements

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