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Advances in Airborne Molecular Contamination in 300 mm Process Technology

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Comprehensive AMC prevention, removal and monitoring concepts are an integral part in any advanced total contamination free environment for high-yield 300 mm manufacturing. This article will elucidate the integration of such an advanced concept in a 300 mm process technology wafer fab employing 0.18µm technology and state-of-the-art monitoring instrumentation.

Introduction

The transition of the microelectronics industry to 300 mm process technology necessitates the development of advanced business and technology fab building concepts to comply with the tight time-to-market and contamination free manufacturing requirements.

The introduction of the 300 mm technology has forced the creation of new concepts, particularly in the area of the complete elimination of contamination sources and control through out the entire manufacturing process chain. Progressive improvements in Fab design to match continuously new process requirements related to reduced feature sizes and the introduction of new processing materials, normally occur as a gradual shift compared with the finite steps in increased wafer size. However, between the "chemisphere" of the wafer and the cleanroom environment there are numerous sources contributing to contamination and thus to yield losses.

In anticipation to the promising results with respect to the current levels of productivity of 300 mm process equipment and the economic benefits to be gained in terms of reduced cost per die, a number of semiconductor manufacturers are considering the conversion of selected wafer fabs. When considering a potential conversion of an existing wafer fab from 200 mm partial or full manufacturing to a 300 mm environment, multiple factors need to be taken into account and analyzed. These range from upgrades in the building and facilities systems including also the contamination control in the cleanroom.

As feature sizes shrink, the presence of Airborne Molecular Contamination (AMC) becomes a significant technology barrier [1-12]. For example, it is no longer possible to manufacture feature sizes below 0,1 µm in the lithography without a complete AMC control program. This indicates that we are approaching a similar technology barrier in the production and handling of the latest technology reticles.

The introduction of copper metalization requires also a specific contamination control program since IC manufacturers report significant yield loss because of corrosion effects due to the lack of advanced AMC removal concepts. High spills of AMCs can fatally damage expensive ICs.

The challenge to develop total contamination control solutions for 300 mm process requirements was taken up by M+W Zander.

Airborne Molecular Contamination

This article describes the recommended analysis and considerations required when examining an existing 300 mm wafer fab in form of a generic case study. This study, assumes an existing 300 mm wafer fab in production with 0.18 µm CMOS technology running at 70% of the planned final capacity with 80% of the process equipment already installed and operational.

Successful IC Manufacturers are sometimes not affected by major downturns in the semiconductor industry. However, the increased competitve conditions may lead to operating marging reductions and force the management to take measures to increase profitability and reduce yield losses. In some cases the assessment and determination of the benefits related to the introduction of an effective integrated AMC control concept have been considered with the anticipated results.

Overall Approach

Electronic manufacturers who have encountered AMC control realize that they can maximize profitability by means of a comprehensive integrated contamination control concept.

Implementation of an integrated AMC removal concept in an operational 300 mm wafer fab including possible extensive modifications to the facility systems was identified as a major challenge. Accordingly, it was recognized that a careful and detailed baseline analysis had to be performed prior to any implementation. For that purpose M+W Zander with significant experience in the relatively new field of 300 mm process technology has been selected to provide a comprehensive AMC concept. By utilizing the synergies between the client`s and M+W Zander`s experts the following procedures have been kicked-off.

Figure 1: Increased wafer size requires enhanced AMC contamination control

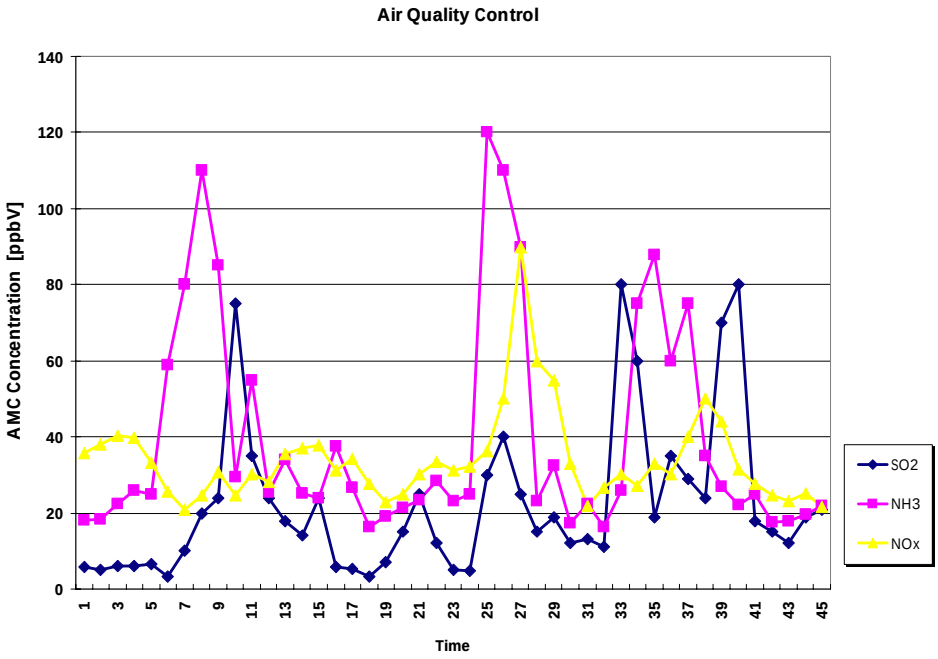

Figure 2: Typical AMC level in a cleanroom air **without** AMC treatment

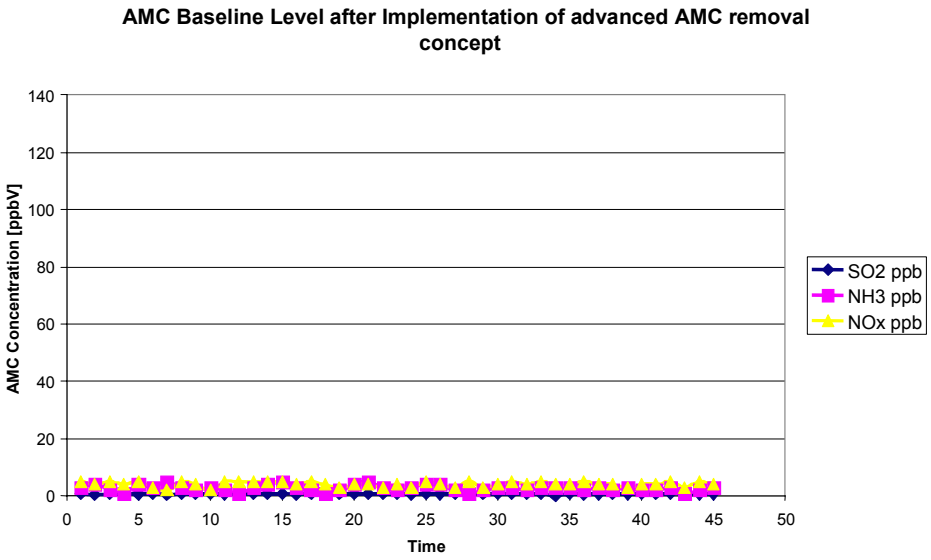

Figure 3: Typical AMC level in a cleanroom air **with** AMC treatment

Definition of Process Requirements

The client initiated the evaluation process in form of a study to define the specific process related contamination control requirements focusing first on photolitho and copper area. Furthermore, an initial AMC baseline analysis was performed to determine the quantities and the sources of AMCs in the cleanroom. The first step towards a comprehensive contamination control concept is a careful analysis of the AMC levels in the cleanroom air system. M+W Zander has developed a state-of-the-art measurement technology capability inhouse. This features ion chromatography (IC), gas chromatography mass spectrometry (GC MS), inductive coupled plasma mass spectrometry (ICP MS) and on-line monitoring systems to cover the whole range of gas phase air measurements. Sensitive tools for sub-ppb/ppt trace level analysis need a well-controlled environment. All of the trace level measurement devices are located in cleanrooms in the M+W Zander Technology Center.

Concept development

After determining the AMC level in the make-up air and in the cleanroom, the contamination control experts worked out a state-of-the-art integrated AMC removal concept featuring the source of the AMC and by considering the outside air treatment, the cleanroom and the minienvironments. From the safety and economical point of view integrated AMC solutions have to be considered instead of single point AMC filtration to control high levels of AMC in the cleanroom. In the present study different solutions to control the AMC concentration in the manufacturing environment were considered.
In parallel a cost of ownership model was performed to demonstrate and confirm the financial advantage of the suggested solution.

A key element in contamination control is to fully understand the science behind AMC control and to work together with the client, researchers and institutes.
The best in class AMC removal technologies assessed and qualified by M+W Zander are essential for a reliable,

safe and cost-effective contamination control solution. In conjunction with continuos benchmarking data M+W Zander is able to provide a tailor-made solution with emphasis on technical excellence and low cost of ownership according to the specific client requirements.

Subsequent to the AMC removal concept development featuring a detailed cost of ownership calculation it was decided to implement this concept in the existing facility. By that means a well-controlled cleanroom environment with stable operating conditions and a comprehensive AMC control including the complete cleanroom air system was guaranteed and verified by certification measurements.

Summary

All in all, the integration of a comprehensive integrated AMC removal concept is a necessity for current and future submicron IC manufacturing. Special attention however must be given during the implementation of such a concept while the fab is in operation. It is therefore essential for any project to commence all activities with baseline AMC measurements under simultaneous careful planning and scheduling with process and facilities.

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About the Author

Klaus Kümmerle graduated a degree in physics from the Technical University of Heilbronn in 1995. The same year he joined M+W Zander and is responsible for all aspects of contamination free environment in the semiconductor and related high technology fields. Mr. Kümmerle has contributed to several publications covering airborne molecular contamination control.

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