Comparison of X-Ray and Mass Spectroscopy based Analytical Methods for Detection of Organic Contamination

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ABSTRACT

The impact of organic contamination on wafer surfaces on the functionality of nanostructures and advanced microelectronics becomes crucial as the continuously shrinking feature sizes become similar to the dimensions of molecules and clusters of molecules. For the studies the methods used were synchrotron radiation based Near Edge X-ray Absorption Fine Structure analysis (NEXAFS) in the soft X-Ray range at the absorption edges of light elements (e.g. C, N, O, F) combined with reference-free Total-reflection X-Ray Fluorescence (TXRF) analysis, Thermal Desorption Gas Chromatography Mass Spectrometry (TD-GCMS), and Time of Flight Secondary Ion Mass Spectrometry (TOF-SIMS).

In this paper manufacturing processes from both manufacturers of starting materials and of highly integrated circuits are studied. Analysis was focused on the organic contamination release during final wafer manufacturing phases. A test matrix has been designed and performed involving the three different analytical techniques. Figure one shows that the contamination level of volatile organic compounds is increased in the final clean area when sample surface is abnormally exposed to air filtration for prolonged periods. The results are in line with TXRF-NEXAFS analysis. The second study was focussed on the efficiency of 193 nm immersion photo resist removal and cleaning. Figure 1 demonstrates that the resist ashing process acts as a cleaning step for organic contamination from the environment. This result is obtained from both TOF-SIMS and TD-GCMS measurements. Furthermore, it was proven that no resist residua are found after cleaning and that sulfur and NHx compounds are left by wet cleaning steps (SPM+SC1). TOF-SIMS confirmed that the oxygen plasma cleaning leaves an oxidized surface.

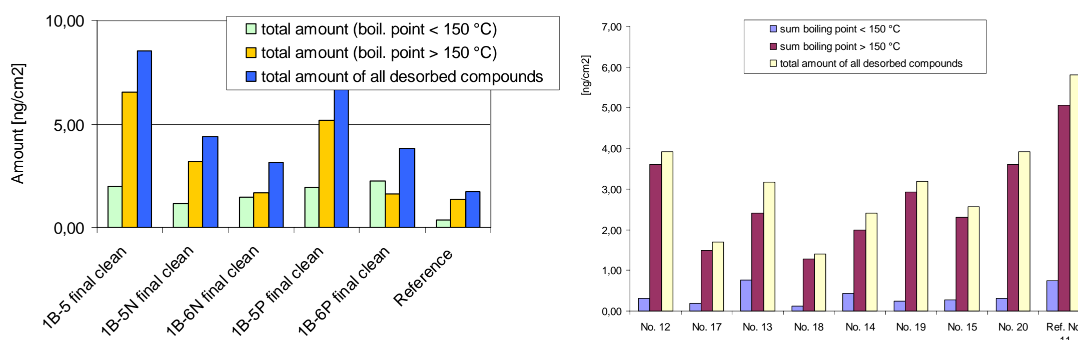

Figure1: Semi-quantitative amounts of detected volatile organic compounds in ng/cm^2
<u>left:</u> on wafers (1B-5/6 and reference 11) when abnormal conditions are applied in final clean environment.
<u>right:</u> on wafers (No. 12-20 and reference 11) after cleaning processes in the lithography process.

The approach to study organic contamination on wafer samples using different analytical tools enables the detection of the whole range of organic compounds including non-volatile and volatile ones. TD-GCMS detects the VOC and TOF-SIMS and TXRF-NEXAFS strength are the detection of non-volatile organic surface residues. Additional strengths of TXRF-NEXAFS and TOF-SIMS are the capability of stating on chemical states and surface conditions allowing conclusions on contamination mechanisms. The combination of different analytical metrology tools for characterization of samples is a promising approach to gather information on organic contamination and contamination mechanisms.