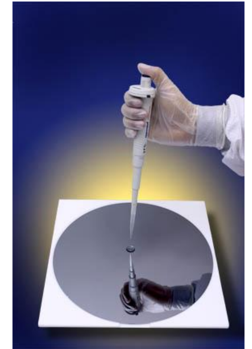
Evaluation of Impurities in High-K and Low-K Thin Films Produced from Advanced Precursor Materials



New materials are rapidly coming into use in semiconductor manufacturing to accommodate shrinking feature size at the 45 nm node and beyond. Metal oxides and oxynitrides based on hafnium, zirconium, and others offer an attractive high-k (dielectric constant) replacement for silicon dioxide in transistor gates and other sensitive structures. These oxide films are typically formed by CVD (chemical vapor deposition) using a volatile precursor compound to deliver the desired metal in the vapor phase to the wafer surface. Subsequent reactions on the surface result in the desired oxide film.

Problems have been encountered in the preparation of high-purity precursor compounds for use in CVD. Zirconium and hafnium, for example, occur together in nature, and are extremely difficult to separate. Other contaminants such as aluminum and titanium are also commonly found in CVD precursor compounds. If the CVD precursor compound used in wafer processing is contaminated with impurities, contamination of the resulting film on the wafer surface is unavoidable. The presence of contamination in structures such as a transistor gate can cause undesirable effects on the function of the transistor, and can ultimately lead to device failure.

Elemental analysis of the native precursor compound has been used to quantify trace elemental contaminant. Acid digestion and dilution methods followed by analysis via ICP-MS utilizing a dynamic collision cell or high mass resolution instrument have been instrumental in monitoring low ppb level contaminants which provides an effective QA/QC regime.

High-K thin films are produced under high vacuum and the precursors decomposed utilizing various chemical reactions and thermal processes. These reactions may drive off certain trace elemental species while concentrating other elemental contaminants, and therefore it may be necessary to study the elemental contaminants in the thin film to compare with the contaminants in the bulk precursor. Additionally, this comparison may yield important information regarding the impact of deposition tool and process on the level of elemental contaminants in the processed thin film.

Advanced thin film analysis techniques such as DSE (Drop Scan Etch) are effective in preparing samples for the analysis of low level contaminants in manufactured High-K and Low-K thin films. This analysis technique relies on NIST traceable elemental standards to provide accurate analysis. A wide variety of advanced thin films have been analyzed utilizing these methods.

For additional information, please contact us.