Abstract

Ternary compound materials are gaining substantial attention with the development of semiconductor technology. Owing to their comprehensive applications, precisely quantifying the matrix composition of ternary compounds has become increasingly vital. In this context, surface analysis techniques are crucial to facilitating accurate characterization for advancing material science. Applying secondary ion mass spectrometry (SIMS) is challenging among these techniques due to the impact of the matrix effect. The matrix elements in a material influence the secondary ions ejected from the surface, causing variations in ionization yield with the compound's composition. The matrix effect is related to changes in the material's electronic properties, such as work function.

This study investigates matrix effects in the SIMS analysis of ternary compound semiconductors. To assess how matrix composition influences secondary ion yield and the accuracy of composition determination. The thesis is divided into two main sections: the first part focuses on matrix effects in the $Cd_{1-x}Zn_xO$ ternary compound, while the second explores matrix effects in $Pb_{1-x}Sn_xTe$.

$Cd_{1-x}Zn_xO$ ($0 < x < 0.6$), a widely used ternary compound semiconductor popular mostly in optoelectronic applications, and $Pb_{1-x}Sn_xTe$ ($0 < x < 1$) another applicable ternary compound demonstrates non-linearity in band structure near critical composition points, making it an ideal candidate for studying the matrix effect. It should be noted that while the matrix effect complicates the quantitative analysis of the material composition, it concurrently allows for valuable inference about the electronic and chemical properties of the studied semiconductor.

A contribution of this research is the development of a calibration curve method using SIMS to determine the composition of CdZnO and PbSnTe ternary compounds accurately. With the use of these calibration curves, we can accurately measure the elemental composition of $Cd_{1-x}Zn_xO$ and $Pb_{1-x}Sn_xTe$ in any structure, which is difficult to achieve with other methods. An innovative aspect of this study is introducing a new approach for SIMS instruments, allowing for estimating the band gap behavior of ternary compound semiconductors of $Pb_{1-x}Sn_xTe$ for the first time while accounting for the matrix effect in SIMS analysis.

This study advances the understanding of matrix effects in SIMS analysis, which is crucial for improving the accuracy of material characterization. Ultimately, the research aims to develop more accurate and reliable analytical methods, supporting fundamental research and practical applications in the semiconductor industry.