ATOMIC LAYER BY LAYER DEPTH PROFILE OF MUSCOVITE BY SECONDARY ION MASS SPECTROMETRY

VELIC Dusan, JERIGOVA Monika, SZOECS Vojtech, JANEK Marian, LORENC Dusan

International Laser Centre, Bratislava, Slovakia, EU
Comenius University, Faculty of Natural Sciences, Bratislava, Slovakia, EU

Abstract

Nanotechnology is advancing materials and manufacturing processes on the dimensions of 100 nm. Further progress in nanotechnology might result in new nanomaterials with unique properties e.g. optical, magnetic, or catalytic. Solid surface structures represent nanomaterials with enormous potential. In order to progress, both, the manufacturing process and also the analytical characterization, should provide sufficient resolution. Secondary ion mass spectrometry (SIMS) is unique surface sensitive analytical technique which provides not only chemical composition and isotopes, but also three dimensional spatial chemical analysis called depth profile. Resolution and sensitivity of the depth profile are still of interest and are evaluated on muscovite, which is the mica group phyllosilicate mineral with K0.70Na0.11Ca0.01[Si3.07Al0.93][Al1.88Fe0.12Mg0.05]O10(OH)2 formula. This mineral readily cleaves into thin sheets with single layer thickness of approximately 1 nm with a periodically repeating chemical structure. The SIMS depth profile reproduces the periodic structure as the oscillating SIMS signal intensities of all muscovite atoms and molecular fragments. These atoms and fragments in cationic form are well represented by Na, O, Si, SiO, and Fe, with assigned absolute (relative) positions of surface 0.00 (1.60) nm, 0.16 (1.76) nm, 0.19 (1.79) nm, 0.24 (1.84) nm, and 0.39 (1.99) nm, respectively. These profilometer calibrated positions are in excellent agreement with the single muscovite layer. Moreover a novel approach to fit dynamic SIMS data is presented and an intermixing process, which is suppressing the signal oscillation, is discussed. The depth profiles are fitted with Fourier transform providing frequency pattern with time and chirp parameters. The species of Na, O, Si, SiO, and Fe have on average the time of the period of 7.7 s. Their very similar values of time of the period support that the analysis is performed from the single muscovite layer. The proposed damped chirp function might be a potential tool to evaluate the sputtering-intermixing-SIMS oscillating mechanism. This mechanism is crucial to understand, in order to reliably analyze also artificial nanostructures.

Keywords: SIMS, Secondary Ion Mass Spectrometry, layered silicates

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