Chemical State Analisis of Cr Compounds Using Heavy ion PIXE

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Introduction

The toxicity of heavier elements differs widely in their chemical state as well as there concentrations. Therefore, trace heavy element analysis with their chemical state and high sensitivity is of great importance for environmental monitoring. Particle induced x-ray emission (PIXE) is a powerful technique for quantitative analysis. Usually proton beams with an energy around 3 MeV are used in PIXE offering high sensitivity[1)]. Since chemical shift is very small and difficult to measured with conventional Si(Li) detector, high sensitive measurement with chemical state is impossible in this condition.

The sensitivity of PIXE strongly depends on the X-ray production cross-sections, which are proportional to the square of the projectile charge[2)] it can be expected that the use of heavy ion beams will improve the sensitivity of the analysis considerably. The lower limit of detection (LLD) in the PIXE analysis using 70 MeV carbon ions is improved 2-4 times compared to that using proton bombardment for heavier elements[3)].

Since chemical change due to chemical state of the elements will be expanded due to multiple ionization, it may be measured with a conventional Si(Li) detector. In the last report, the three parameters, the relative change of an intensity ratio of k_{β} and k_{α} (Intensity Ratio), a ratio of k_{β} and k_{α} line width (line width ratio) and an energy difference between $k_{\square}$ and k_{α} line (relative energy shift), were measured using 70 MeV carbon ions and 3 MeV protons. Changes in those parameters were corresponds to their chemical state. It shows that PIXE with heavy ions will lead to chemical state analysis with high-sensitivity. Here, the Ar ion beams of 78 MeV are applied to chemical state analysis using PIXE. Probability of multiple ionization for Ar ion beams of 78 MeV is higher than that for C ion beams of 70 MeV, which will increase sensitivity in determining chemical state with high sensitivity.

Experimental

Experiment for Ar ions was carried out at Cyclotron Radioisotope Center. Samples are $Cr_2(SO_4)_3$, $CrCl_3$, $Cr(NO_3)_3$, $K_2Cr_2O_7$, Cr metal, CrB_2, Cr_2O_3, CrB and $CrF_3.3H_2O$. The targets were placed at an angle of 45° with respect to the beam direction. X-rays emitted from the target were measured at an angle of 90° with respect to the beam direction, by a Si(Li) detector. 1 mm Mylar film was placed in front of the Si(Li) detector to reduce pile-up events. The energy calibration was obtained with characteristic x-rays from a ^{241}Am source.

Results

The relative change of an intensity ratio of k_β and k_α (Intensity Ratio), a ratio of k_β and k_α line width (line width ratio) and an energy difference between k_β and k_α line (relative energy shift) for Ar ions is shown 3-dimentionally in Figure 1, in comparison with the results for protons and carbon ions. The changes of these parameters are within experimental errors except for intensity ratio in case of proton bombardment and difficult to specify chemical state of the elements. In case of carbon and Ar ions, changes in parameters seem to correspond to chemical states. However, tendency of these parameter changes corresponds to chemical state is different for these ion bombardments. Figure 2 shows the 3-parameters results for mixed samples which contains elements of different chemical states with different composition. As expected the previous results in Fig. 1, values of mixed samples on these parameters are close to the values of the sample in single chemical state. Since these measurements were carried out within a few minute, PIXE with Ar ions will lead to chemical state analysis with high-sensitivity.

Acknowledgements

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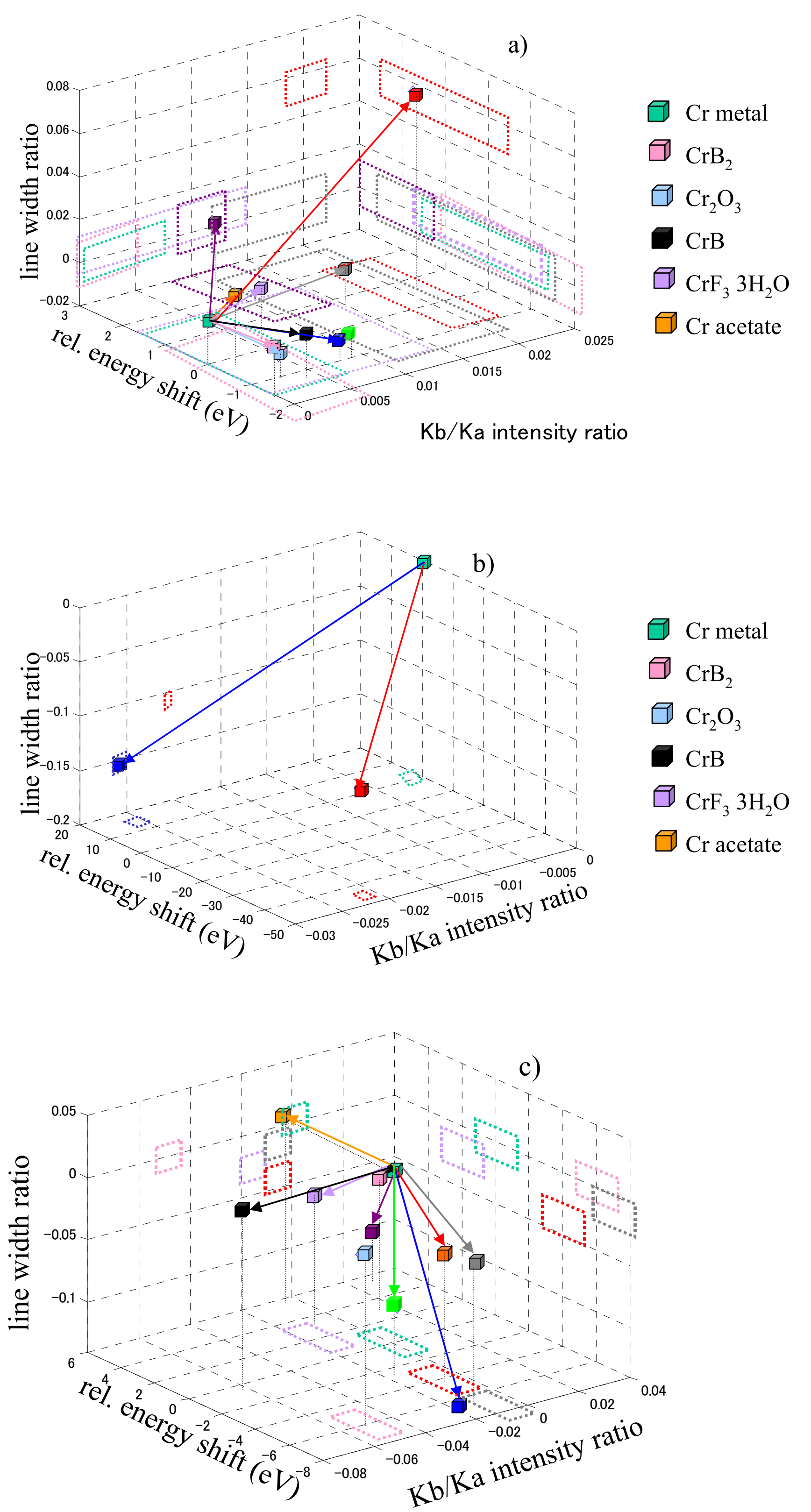

Figure 1. The relative change of an intensity ratio of k□ and k□(Intensity Ratio), a ratio of k□ and k□ line width (line width ratio) and an energy difference between k□ and k□ line (relative energy shift) for proton, carbon and Ar ions.

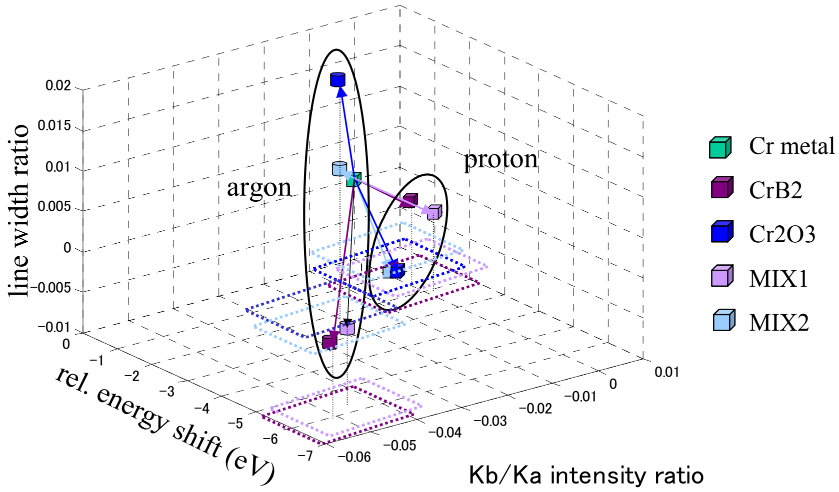

Figure 2. Relative changes of the 3 parameters of mixed samples for proton and Ar ions.