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Property Map by Electron Spectroscopy Imaging Series

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Electron energy loss spectroscopy (EELS) provides powerful method to quantitative characterization of important property of materials such as composition, energy band gap, dielectric function, chemical bonding and electronic structure. In order to reveal in-homogeneity in the material, two dimensional EELS information with high spatial resolution is required. Two spectroscopic imaging methods have been developed to implement 2-D EELS. The first technique, known as the spectrum imaging method, is to acquire a 2-dimensional EELS spectrum by scanning the focused electron beam across the sample. This method was proposed by Jeanguillaume and Colliex in 1989 [1]. The other method is known as electron spectroscopic imaging (ESI) or image spectroscopy, which extracts the spectrum at a specific position from a series of energy loss images [2]. The advantage of the spectrum imaging method is that the energy resolution, which is about 0.3~1eV depending on the type of electron gun and the accelerating voltage, is better than for electron spectroscopic imaging (ESI) which is 4-20eV depending on the width of the energy-selecting slit. However, the drawbacks of spectrum imaging are the radiation damage of beam sensitive materials and a longer acquisition time than required by the ESI method [1].

Bottlenecks in the ESI method for quantitative analysis are under-sampling and loss of energy resolution, since the energy loss image series are acquired with finite size of energy slit and discrete energy step. A set of signal processing methods has been successfully developed for process electron spectroscopic images (ESI) series. In my talk, I will demonstrated the application cases of ESI to mapping of sp_2/sp_3 ratio [3] , dielectric function[4], energy bandgap[5], valence state[6]. Figure 1 shows a zero loss image of Cu/Fe/ Fe_2O_3 thin film. The ESI image series was acquired with 4eV energy window and 2 eV step. Typical spectra extracted from the Fe and Fe_2O_3 thin films are shown in Fig. 2(a) and (b). The L2/L3 are clearly revealed for both cases. The resultant L2/L3 map is shown in the Fig. 3.

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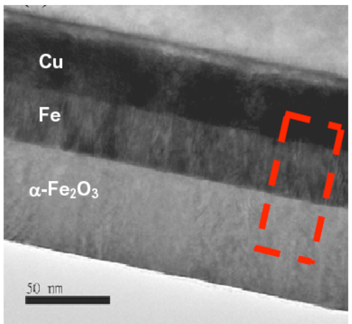

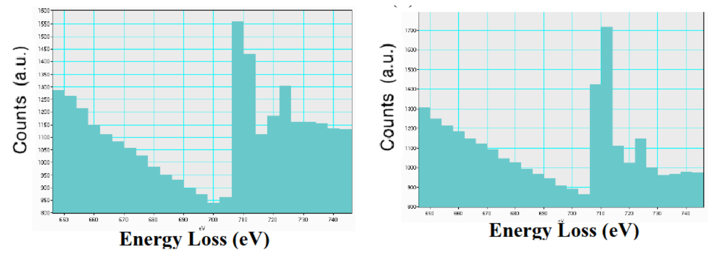

Fig. 1. A zero loss image of Cu/Fe/ Fe_2O_3 thin film

Fig. 2 the retrieved spectrum from (a) Fe and (b) Fe_2O_3 thin film

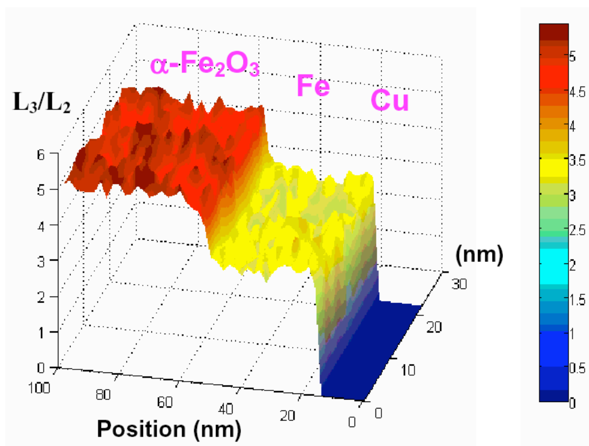

Fig. 3 the L2/L3 valence state map of the red boxed area in Fig. 1

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