Double photoionization of F in CaF_2

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INTRODUCTION

In inner shell photoionization of low atomic number elements, multiple excitation processes occur with significant probability. Double ionization processes for inert gas atoms such as He, Ne and Ar have well been investigated experimentally[1)-4)] and have been understood theoretically[5)6)], based on three mechanisms, i.e. (1) the absorption of a photon by a single electron followed by the interaction of the photoelectron with the remaining orbital electrons, (2) the shake off, and (3) the ground state correlation. However, the double ionization probabilities in solids are less prominent[7)], and have dependency on change in chemical environments[8)9)]. Representative solids to show such a dramatic change in the multiple ionization probabilities are fluorides, and then CaF_2 was chosen here for a test material whether or not the ratio of double to single ionization can be determined with enough measurement accuracy at the 8.0.1 beam line within a few hour experiment.

EXPERIMENTAL RESULTS AND DISCUSSIONS

F Kα emission spectra of CaF_2 shown in Fig. 1 were measured using a grating monochrometer at B.L.8. Excitation energies are written at the right hand side of Fig. 1, where K^1L^0 and K^1L^1 denote initial states of X-ray emissions, i.e. one vacancy in K and no vacancy in L, and each one vacancy in K and L, respectively. Namely F Kα X-rays, noted as K^1L^0 and K^1L^1, are emitted from singly and doubly ionized initial states of F in CaF_2. Energy calibration for the reported emission spectra was obtained by assuming the energy of K^1L^0 to be 677.2eV[10)]. The intensity ratio of the K^1L^0 line to the K^1L^1 line versus the excitation energy is plotted in Fig. 2. By assuming constant fluorescence yields for the K^1L^0 and K^1L^1 states, one can interpret Fig. 2 as a plot of the ratio of the double ionization cross section to that of single ionization. Increasing tendency of the ratio versus the energy is the same as that for the ratios for He, Ne and Ar, where the latter ratios reach their maximum between 100 and 250 eV above their threshold energies. Such experimental results obtained here indicate that a series of F Kα emission spectra taken from fluorides by changing the excitation energies are to be good candidates for explaining electron-electron correlation in solids.

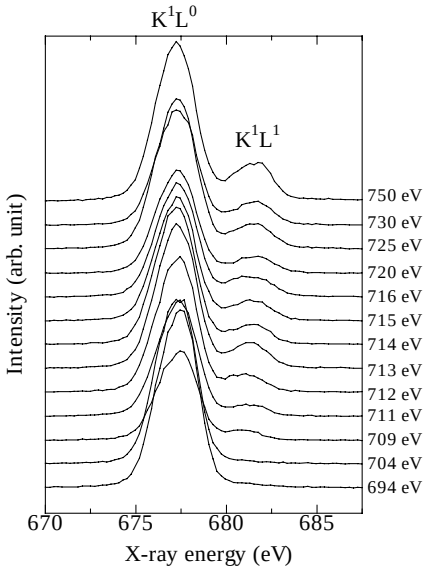

Fig.1 F Kα X-ray spectra of CaF_2. Energies of incident X-rays are indicated at the right hand side.

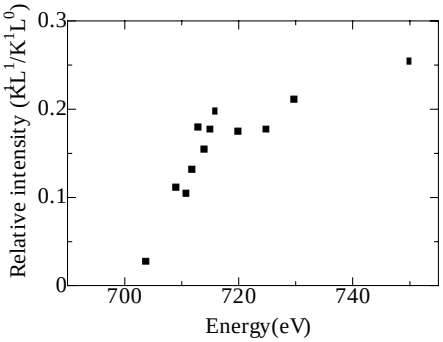

Fig.2 Relative intensity (K^1L^1/K^1L^0) of Fα X-rays emitted from CaF_2.

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