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Effects on measurement of photon-atom scattering of applied pressures on sample at different thickness

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Abstract

$N_{\mathrm{coh}}/N_{\mathrm{Comp}}$ and NK_{β}/NK_{α} intensity ratios of scattered photons by Zn in the linear region and the infinite mass thickness region are measured as functions of the pressure used for compressing the pellets with a Si(Li) detector using Am-241 and Fe-55 annular source. Besides, the effect on the experimental intensity ratio of relation between two different thicknesses of sample with applied different pressures on the sample is investigated in this study. Harmony between the linear and infinitive (critical) thickness region and the applied pressure on the sample has directly affected the experimental intensity ratios. Experimental results were not compared with various theoretical values in the literature, for present results constitute the first experimental measurements.

Keywords: Photon-atom scattering; Intensity ratio; Mass thickness

1. Introduction

Scattering of photons by atoms, molecules and solids is an important method for obtaining information about the structural properties of materials. Photon-atom scattering is also important in simulations of radiation transport in complex systems [1]. The scattering of photons, which is the basic mode of their interaction with matter, has been the subject of considerable interest.

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A knowledge of coherent and incoherent scattering of photons, especially at low energy (10–100 keV), has been added to the total cross-section because of its application in various fields [2]. Coherent scattering is also an important process of photon interaction below 1 MeV. Coherent scattering is used in such diverse applications as medical gamma X-ray technology, power reactor shielding, industrial radiation processing and analysis of nuclear physics experiments [3]. Scattering events acquired additional importance from their potential use in bio-medical problems, and also scattering measurements are used to determine several physical quantities such as electron density, target mass and mass density. Also, intensity ratio is considered a characteristic quantity for each element. The accurate determination of intensity ratio is important because of its wide use in non-destructive trace fluorescence techniques and in the fields of atomic and radiation physics. Numerous experiments have been carried out to see various effects for different samples in X-ray fluorescence analysis. For example, Boshkova and Minev [4] proposed an approach to determine the full-energy peak efficiency dependence on the sample density. Sidhu et al. [5] investigated the combined effect of sample thickness and collimator size on the apparent mass attenuation coefficient of soil and water for 662 keV γ-rays. Mzyk et al. [6] researched on grain size effect in X-ray fluorescence analysis of pelletized samples and calibration with an internal standard applied to eliminate particle size effects for powdered samples. Tartari et al. [7] studied the spectra of gamma radiation, multiple-scattered by large volume samples in different irradiation conditions and positions of sensitive volume (SV) defined by the intersection of the incoming beam and solid angle seen by a detector collimation and, as a result, showed that the non-linear dependence of the multiple-scattered fraction on the SV position inside the sample volume must be taken into consideration in assessing Compton tomography techniques. Zagorodniy [8] has utilized pressure for pelletized samples in the present experiment. As a result, the parameters (particle size, powder bulk density, packing density and applied pressure on sample) were found by Zagorodniy to have a great effect on the fluorescence intensity of powder materials. Separately Zagorodniy has researched the effect of surface roughness of powder sample (μm) at different pressures (kN). Variation according to different pressure and particle size of Zn Kα intensity (k counts/min) has been studied by Bertin [9] for both different pressures at range 0–20 (ton/inch^2) and different particle sizes in the range 30–300 μm. İçelli and Erzeneoğlu [10] confirmed the pressure effect on the K_β/K_α intensity ratio in a powdered zinc sample for the two mass thickness region. Bao et al. [11] have fitted the non-linear relation between absorption coefficients and continuous scattered intensity by a quadratic equation and, as a result, a more suitable absorption correction method compared with the traditional scattered internal technique has been recommended for matrix absorption correction in X-ray fluorescence spectrometry. In chemical methods of sample preparation, the combination of microwave and pressure digestion allows quantitative recovery of elements that may be volatilized in open digests (like Ge, Se, Hg, Pt, Os, and Ir) as well as the recovery of rare trace metals (Pt, Os, and Ir) to the ppb level in solid samples even in the extremely difficult digestion of organic-rich material [12]. Bazan and Bonner showed a linear relation between the effective absorption coefficient (defined as the sum of the sample absorption coefficients for exciting and characteristic X-rays) and the ratio of incoherent to coherent scattering. Markowicz found theoretically that the sensitivity of absorption correction via the incoherent/coherent scattered X-ray intensities ratio is better than that of the absorption procedure involving each of the scattered radiations individually. For intermediate-thickness samples, in a limited range of rather small values of mass per unit area, the intensities of