RESEARCH PAPER

γ-Ray Attenuation Parameters of $SrTiO_3$ &$SrZrO_3$

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ABSTRACT

Investigation on attenuation of γ- Photons and the related parameters in $SrTiO_3$ and $SrZrO_3$ has been done. The (μ_m) of each compound at distinct γ- energies is reported. Also, the investigation was extended to evaluate other important parameters - liner attenuation coefficient, effective atomic and electron numbers etc. The determined values are compared with values obtained from X-Com and using the empirical relations.

Keywords: Attenuation; Total and Electron Cross sections; Effective Atomic and Electron Numbers

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INTRODUCTION

Strontium Titanate ($SrTiO_3$) is a material used in engineering labs to medical research such as Biocompatible Implants, Biomedical Sensors etc. Strontium Zirconate ($SrZrO_3$) have exceptional thermal stability, chemical resistance, and proton conductivity, making it most valuable in energy, electronics, industrial safety systems, combustion monitoring, high-temperature environments and biomedical technologies like Biocompatible Ceramic Coatings, Bone Regeneration Research and a better shielding material.

Study on various properties of $SrTiO_3$ [1] reveals that it behaves as semiconductor with E_g = 2.68 eV. X-Ray Diffraction studies [2] were performed on $SrTiO_3$ and $SrZrO_3$. The experimental and theoretical study [3] on shielding characteristics against radiation of perovskite ceramic ($SrTiO_3$) with 1% Rb and Y doped, leads to the calculation of different parameters at various photon energies. The Doping raised the attenuation coefficients in the low energy range, while the impacts were restricted at elevated energies and hence can be used for shielding and dosimetry. A theoretical equation for attenuation at elevated temperatures is presented [4]. The radiation shielding characteristics of $SrTiO_3$ perovskite ceramic added with varying quantities of tungsten trioxide nanoparticles has been investigated [5] and attenuation parameters were determined with a conclusion of an improvement in the shielding abilities. The attenuation in strontium zirconate-coated steel substrates were examined [6] using different gamma sources. Earlier, various methods have been used to determine Photon interaction parameters of different materials [7-10]. Author, has employed narrow collimated beam transmission method [10]. The interesting characteristics, role of these compounds were noticed. The energy dependent attenuation studies on the compounds are meager in the literature. These observations prompted us to carry out the present study.

2. Experimental Details

Sample pellets of $SrTiO_3$ and $SrZrO_3$ are prepared by 25.5 gm and 27gm of powder using Hydraulic press at pressures of 2200psi and 2400psi respectively. Thickness of the pellet is 140 cm and 1.51cm. The methodology and the experimental setup are presented in detail by the author [7-8].

Mass attenuation coefficient (μ_m), of each compound is determined by the procedure discussed [7] using γ–photons of ^{241}Am, ^{137}Cs and ^{60}Co energy sources. Each sample is irradiated with the radiation emitted by each of the sources. The transmitted intensities before (I_o) and after the sample placed (I) in the beam's path are noted for duration of 15 minutes, under the photo maxima of Gaussian distribution by the detector [7].

2.1. Computational Details

Mass attenuation coefficient (μ_m) of each sample, for every γ-energy is experimentally determined using Eqn. 1 of section III [7]. Mathematically, the value is calculated using Eqns. 2&3 of section III [7]. The theoretical values are also noted from X-Com. Other photon attenuation parameters at every γ-energy are estimated by Eqn (4-9) [7], using (μ_m) obtained in the above three ways.

3. Findings and Analysis

(μ_m) of samples assessed experimentally at diverse γ-energies are contrasted with X-Com values [8] and values estimated using empirical relations [7] in the Table-1. Estimated error in the experimental measurements is about 0.5%. This value is calculated by Eqn. 10[7]. The values of (μ_m) of both samples are shown in Fig.1.As the incident energy increases the probability of absorption reduces. Physical parameters linear attenuation coefficient (μ_l), total photon interaction cross-sections (σ_τ), effective

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atomic number (Z_{eff}), effective electron number (N_{eff}) and photon mean free path (λ) of both the samples, are presented in the Table-1. The agreement of the values is good. (μ_l), (σ_t), (σ_e), and (λ) as a function of γ-energy is illustrated in Fig.2 – Fig. 5 respectively. (λ) has been observed to increase with photon energy, as illustrated in the Fig.5. This is because the likelihood of photon interactions within the material diminishes as energy increases. Z_{eff} and N_{eff} stay unchanged, and are to be unaffected by photon energy.

Table-1, Comparison of Photon Parameters of $SrTiO_3$ and $SrZrO_3$ at diverse energies

E	**0.0595MeV**			**0.662MeV**			**1.173MeV**			**1.332MeV**		
Sample	**x-com**	**Emp**	**Exptl**	**x-com**	**Emp**	**Exptl**	**x-com**	**Emp**	**Exptl**	**x-com**	**Emp**	**Exptl**
μ_m [10^3] m^2kg^{-1}												
$SrTiO_3$	182.4	182.4099	182.36	7.315	7.314707	7.341	5.461	5.460767	5.449	5.116	5.116306	5.113
$SrZrO_3$	285.1	285.0787	284.5	7.342	7.34174	7.338	5.412	5.411607	5.408	5.067	5.067175	5.063
μ_l [10^{-1}]m^{-1}												
$SrTiO_3$	93.2064	93.21146	93.18596	3.737965	3.737815	3.751251	2.790571	2.790452	2.784439	2.614276	2.614433	2.612743
$SrTiO_3$	151.9583	151.947	151.6385	3.913286	3.913147	3.911154	2.884596	2.884387	2.882464	2.700711	2.700804	2.698579
σ_t [10^{25}] barn/atom												
$SrTiO_3$	111.1332	111.1392	111.1088	4.456904	4.456725	4.472745	3.327294	3.327151	3.319982	3.117091	3.117278	3.115263
$SrZrO_3$	214.7492	214.7332	214.2973	5.530301	5.530105	5.527288	4.076544	4.076248	4.073531	3.816676	3.816807	3.813663
σ_e[10^{26}] barn/atom												
$SrTiO_3$	67.85935	67.86303	67.84447	2.721443	2.721334	2.731116	2.031688	2.031601	2.027224	1.903336	1.90345	1.90222
$SrZrO_3$	108.5489	108.5408	108.3204	2.79539	2.795291	2.793867	2.060563	2.060413	2.05904	1.929208	1.929274	1.927685
Z_{eff}												
$SrTiO_3$	16.37699	16.37699	16.37699	16.37699	16.37699	16.37699	16.37699	16.37699	16.37699	16.37699	16.37699	16.37699
$SrZrO_3$	19.78364	19.78364	19.78364	19.78364	19.78364	19.78364	19.78364	19.78364	19.78364	19.78364	19.78364	19.78364
N_{eff} [10^{-23}] electron/g												
$SrTiO_3$	2.687913	2.687913	2.687913	2.687913	2.687913	2.687913	2.687913	2.687913	2.687913	2.687913	2.687913	2.687913
$SrZrO_3$	2.626467	2.626467	2.626467	2.626467	2.626467	2.626467	2.626467	2.626467	2.626467	2.626467	2.626467	2.626467
λ [10^4] m												
$SrTiO_3$	10.72888	10.72829	10.73123	267.5252	267.536	266.5777	358.3496	358.3649	359.1388	382.5151	382.4922	382.7395
$SrZrO_3$	6.580753	6.581244	6.594631	255.5397	255.5488	255.679	346.669	346.6942	346.9254	370.2729	370.2601	370.5654

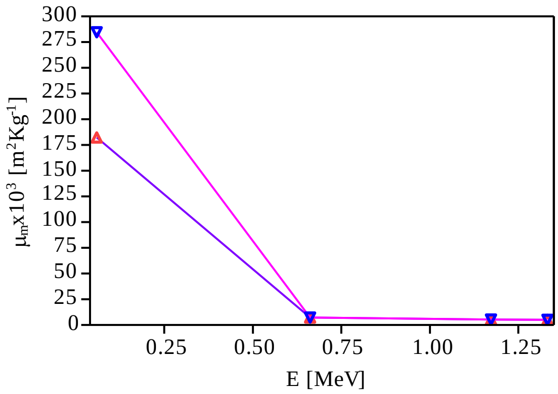

Fig.1. (μ_m) Vs γ- Energy

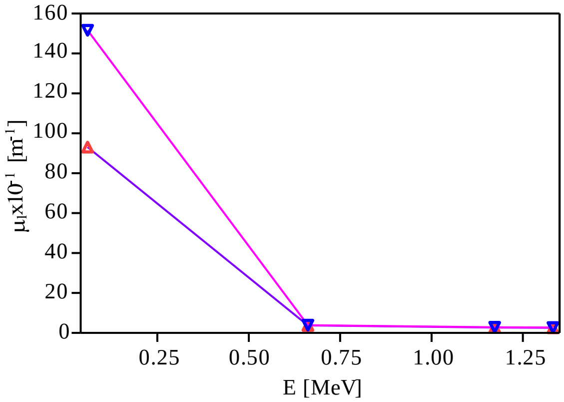

Fig 2 γ- Energy Vs (μ_l)

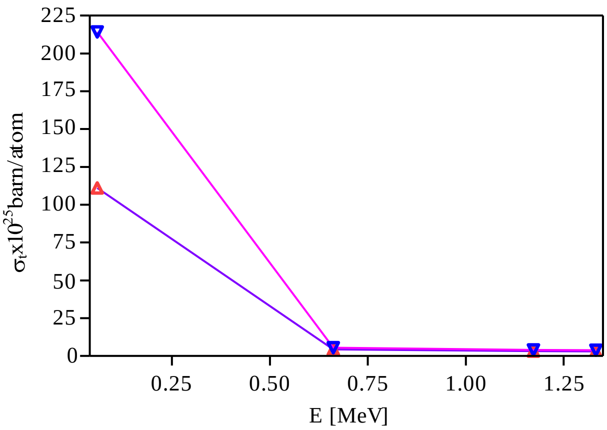

Fig.3. γ- Energy Vs (σ_t)

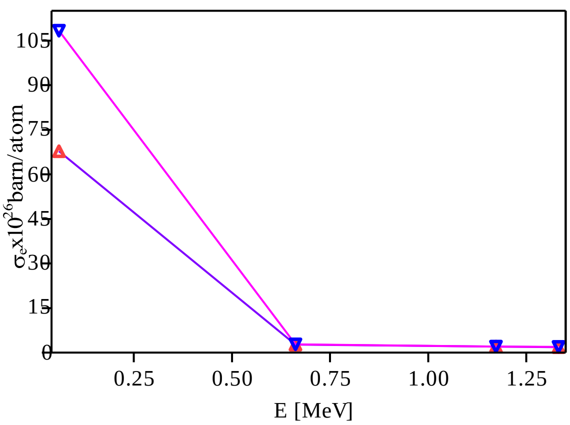

Fig.4. γ- Energy Vs (σ_e)

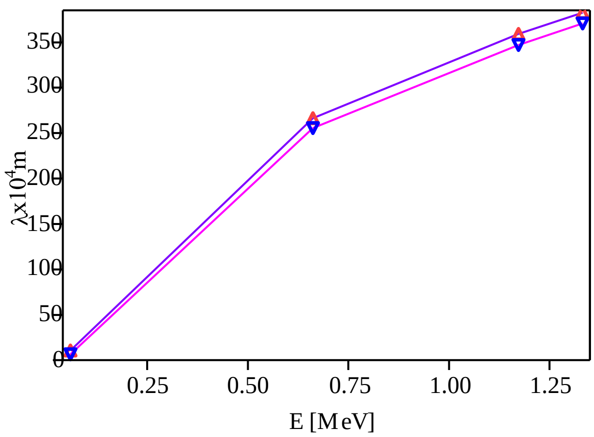

Fig.5. γ- Energy Vs (λ)

4. Conclusions

Investigation on energy dependent γ-photon attenuation in $SrTiO_3$ and $SrZrO_3$ was performed by transmission beam technique. The parameters associated with attenuation were reported for the first time at various γ-energies. The (μ_m) is a vital parameter, helps in calculating all other co-related parameters of specimens. (μ_m) of compounds diminishes as energy increases. The variation of (σ_t and σ_e) with energy is identical to (μ_m). The findings established in this study correlate strongly with the findings through other techniques.

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