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Evaluation of Thin ZnS(Ag) Scintillator Sheet for Alpha-ray Contamination Monitoring during Decommissioning

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1. Introduction

Generally a great quantity of waste was generated during the decommissioning of nuclear facilities. The contamination level of the decommissioning wastes must be surveyed for free release. Among the radiation detectors, alpha-ray contamination measurement has been mainly used a detector consisted with a silver activated zinc sulfide (ZnS(Ag)) scintillator and photomultiplier tube (PMT).

In a previous study [1] a thin ZnS(Ag) sheet were prepared to detect an alpha-particle. The sheet was composed of a transparent polymer sheet and ZnS(Ag) layer. The base polymer sheet was cast from a polysulfone solution using casting method and then solidified. And the ZnS(Ag) scintillator was adhered onto the base sheet using screen printing method. In this study the basic characteristics of the thin ZnS(Ag) scintillator sheet were investigated and the alpha-ray detection abilities were estimated for various preparation conditions.

2. Methods and Results

In this section basic property for a inorganic scintillator and characteristics of a ZnS(Ag) are described. The properties of the thin ZnS(Ag) scintillator sheet are estimated.

2.1 Scintillation production mechanism

In inorganic scintillator the scintillation mechanism is clearly characteristics of the electronic band structure found in crystals (see Fig. 1). When radiation enters the crystal, two principal processes can occur. It can ionize the crystal by exciting an electron from the valance band to the conduction band, creating a free electron and a free hole. Or it can create an exciton by exciting an electron to a band (the exciton band) located just below the conduction band. If crystal contains impurity atoms, electron levels in the forbidden energy gap can be locally created. A migrating free hole or a hole from an exciton pair, which encounters an impurity center, can then ionize the impurity atom. If now a subsequent electron arrives, it can fall into the opening left by the hole and make a transition from an excited state to the ground state, emitting photon if such a de-excitation mode is allowed. If the transition is photonless the impurity center becomes a trap and the energy is lost to other processes.

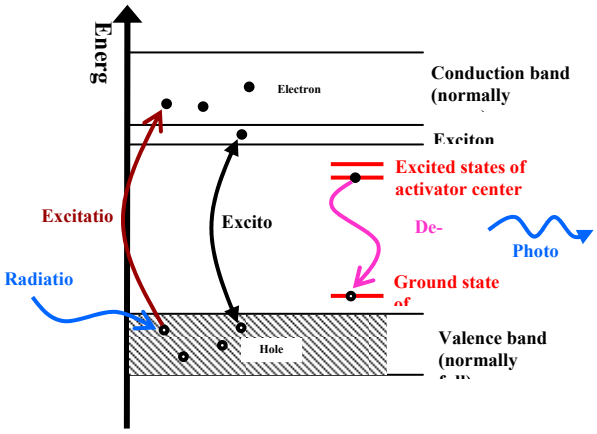

Figure 1. Electron band structure of inorganic crystals.

2.2 ZnS(Ag) scintillator

Silver activated zinc sulfide is one of the older inorganic scintillators. It has a very high scintillation efficiency, comparable to that of NaI(Tl), but is only available as a polycrystalline powder. As a result, its use is limited to thin screens used primarily for alpha particles or other heavy ion detection. Thickness greater than about 25 mg/cm^2 become unusable because of the opacity of the multi-crystalline layer to its luminescence. ZnS(Ag) has a maximum in the scintillation emission spectrum at 450 nm[2].

2.3 Properties of the thin scintillator sheet

The thin ZnS(Ag) scintillator sheet is divided into two parts ; the one is a transparent base sheet made of a polymer and methylene chlorides as a solvent, and the other is a radiation detection layer composed by ZnS(Ag) as a scintillator, polysulfone or cyano-resin as a paste, and dimethyformamide (DMF) as a solvent.

The base polymer sheet plays a role as a support layer and a penetrating medium for the light produced by interaction with radiation and scintillator. So, it must have a sufficient mechanical strength and transparency. The base polymer sheet was prepared using various

polymers such as polysulfone, estyrene, and polystyrene.

The transmission of the base sheet for the visible light was about 90% near blue wave for all polymer sheets, thus they had a high transparency. Also, the mechanical strength of the polymer sheets was measured. In the polystyrene case it was cracked after solidification, thus couldn't be used as a base polymer. But, Polysulfone and Estyrene are showed a similar mechanical strength. Their yield point was 5.8 and 6.6 kgf/mm^2 respectively.

In order to investigate the characteristics of the detection layer according to adhesive materials, polysulfone and cyano-resin were used as a paste. The scintillator solution was prepared by dissolving polysulfone or cyano-resin into DMF and adding the ZnS(Ag) scintillator. The prepared one was printed onto a polymer sheet using screen printing method. ZnS(Ag) scintillator layer using cyano-resin showed good adhesive strength. But, the ZnS(Ag) scintillator using polysulfone as a paste was separated from the detection layer because of weak adhesive strength.

After printing the active layer, the estyrene base sheet was cracked because DMF dissolved the estyrene. Therefore, it was found that estyrene couldn't use as a base polymer in spite of good optical and mechanical property.

2.4 The Alpha-ray Detection of the ZnS(Ag) Sheet

For the alpha-ray detection test of the prepared scintillator sheet, a radioactive solution of a Am-241 emitting alpha particles was spotted onto a ZnS(Ag) scintillator sheet. The amount of scintillation produced by the interaction between ZnS(Ag) and alpha particle was measured using a PMT. The alpha-ray spectra measured using the ZnS(Ag) scintillator sheet and PMT was shown Figure 2. The measured spectra showed the good detection ability for the alpha particles.

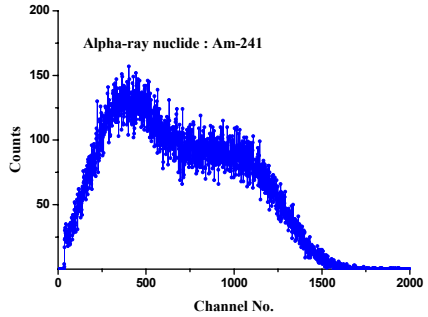

Figure 2. The alpha-ray spectrum of the thin ZnS(Ag) scintillator sheet measured using Am-241 alpha source.

In order to Estimate a repetition of the thin ZnS(Ag) scintillator sheet prepared by using cyano-resin, many sheets of ZnS(Ag) scintillator were prepared and radiation detection ability was measured. The total count rates are showed similar values.

3. Conclusion

A thin ZnS(Ag) scintillator sheet for alpha-ray monitoring was prepared. The ZnS(Ag) scintillator sheet was composed of the ZnS(Ag) layer and the base polysulfone layer solidified from a homogeneous casting solution. The ZnS(Ag) was adhered onto the base sheet using the screen printing method. As a result of the optical and mechanical property, we confirmed that the polysulfone had an excellent ability as a base polymer. The cyano-resin as a paste was excellent than polysulfone in the adhesive strength and alpha-ray detection ability. The prepared polysulfone sheet showed a reliable capacity for the monitoring of the alpha-ray contamination.

REFERENCES

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