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種別(和文)	論文要旨
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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Triboluminescence of ZnS:Mn phosphors dispersed in polymeric material has been investigated on different methods: sliding deformation and impact testing. Because the commercial testing equipment is not designed for measuring the properties, it is important to develop such acquisition setups. For a pin-on-disc triboluminescence measuring apparatus, it composes of three major sections: a mechanical loading mechanism, a load determination circuit and the optical measuring systems. Friction coefficient and a magnitude of normal forces can be simultaneously determined from a deflection of poly(methyl methacrylate) elastic arm. Voltage signals from the gauges are amplified by the cascaded operational amplifier ICs. This setup is used to investigate the influence of applied normal load, volumetric content of ZnS:Mn and frictional conditions. On the other hand, an impact testing method is employed for observing the effect of contacting geometries and impacting energy by utilizing different radius of glass pins and striking angles, respectively. Stronger luminescence can be achieved by a) higher mechanical force/energy, b) reducing of contact area, c) increasing phosphor content in the composite and d) higher coefficient of friction. The results shows a linearity between total emission intensity and applied force/energy. It is important to notify the aforementioned conditions are accounted for high exerting stress. Influence of phosphors content can be explained as a direct increase of light-emittable domain and an indirect governing factor on the effective mechanical properties of the composite. The latter can be confirmed by a noticeably change in track width and damages for different volumetric content of ZnS:Mn particles in the composite.

Modified Hertzian contact mechanics indicates the fact that there is not only a magnitude of force but also the mechanical properties and friction coefficient which govern the sub-surface stress. The von Mises stress which estimated from the response fields is assigned as a uniaxial compression. Luminescence quantity is found to be nonlinearly increased with the applied stress, however, the results are inconsistent to a simple quadratic; it is likely to resemble exponential function.

Taking into account a non-centrosymmetry of ZnS crystals and a conservation of energy principle, a piezoelectricity is responsible for the electromechanical coupling energy generation and therefore produces more energetic electrons. It is possible consider

that the excited particles may deliberate from their shallow traps into conduction bands. Likewise a doping effect in semiconductors, the increment of electrons population in conduction band suggestively corresponds to the shift of Fermi level so that Fermi-Dirac distribution function can be employed for estimating the electron distributing probability and their population in conduction band of host crystals.

The process of triboluminescence proposed in the study are shown as follows:

1. Piezoelectricity-associated enthalpy is produced during the deformation of phosphors.
2. Electric enthalpy contributes to an increase of stored potential energy of electrons.
3. Electrons possibly escape from shallow traps and therefore increase the population of free electrons in conduction band.
4. Luminescent centers may capture holes from valence band while the excited electrons tend to return its lower energy state.

$$(Mn^{2+}) + h^{+} \rightarrow (Mn^{3+})^{*}$$

5. The excited electrons recombine with holes captured in the centers.

$$(Mn^{3+})^{*} + e^{-} \rightarrow (Mn^{2+})^{*}$$

6. The emission of photon is an attribution of de-excitation of the centers.

$$(Mn^{2+})^{*} \rightarrow (Mn^{2+}) + hu.$$

Mathematical model developed based on above mechanism is given as $A[\exp(B\sigma^2)-1]$ where a pre-exponential $\boldsymbol{A}$ includes the following factors: a detector efficiency, a spectral distribution, a volume fraction, and internal efficiency of luminescent centers while a piezoelectric property and crystallographic orientation of ZnS host crystals can be comprehended by an exponent coefficient $\boldsymbol{B}$. Interestingly, its first-order approximation becomes a quadratic function which is consistent to the most frequently cited model.

This is the first research in fields of mechanoluminescence that employs contact mechanics for direct calculation of the apparent stress. In spite of the fact that the theoretical model is relatively difficult to be implemented, it allows us for better understanding a correlation between stress-induced luminescence and external stimulation. Main advantage over the current model developed by B.P. Chandra *et. al* is a straightforward approach for determination of excited electron population in conduction band using well-know Fermi-Dirac distribution function.