The structure of the emission bands of luminescent solids
Vlam, Chr. C.

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
1953

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):

Copyright
Other than for strictly personal use, it is not permitted to download or to forward/distribute the text or part of it without the consent of the author(s) and/or copyright holder(s), unless the work is under an open content license (like Creative Commons).

Take-down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from the University of Groningen/UMCG research database (Pure): http://www.rug.nl/research/portal. For technical reasons the number of authors shown on this cover page is limited to 10 maximum.
SUMMARY

The scope of the investigation was to find a mathematical description of the spectral intensity distribution within a single emission band of a luminescent solid (phosphor) and to examine whether composite emission curves could be represented as the sum of a number of such functions. In this way it should be possible to give an analytic representation of the emission curves in a mathematically closed form, by which the influence of several factors – such as the way of preparation, the activator content, the grain size, the temperature, the way of excitation etc. – on the emission spectrum could be expressed quantitatively by means of the relations that exist between these factors and the parameters determining the mathematical function. For this purpose a number of simple emission spectra were plotted in the following ways:

1. The intensity as a function of wave length \( P(\lambda) \)
2. The intensity as a function of frequency or wave number \( E(\nu) \)
3. The number of emitted photons as a function of frequency \( P(\nu) \).

All the ways of representation mentioned have been applied by earlier investigators, assuming, in the way of representation chosen, a single emission band to be represented by a symmetrical Gauss curve. However, a careful examination (chapter I) showed that a single emission band is only symmetrical in the wave number scale and is represented by the Gauss error function \( I(\nu) = A \exp \left[-B(\nu - \nu_0)^2\right] \), where the parameters have a simple physical meaning.

In chapter II a description of the measuring device together with details of the experimental technique is given. The emission curves of a number of phosphors, determined at temperatures varying between 200K and about 600K, were analysed with the aid of Gaussian functions. A number of examples demonstrates that one function was needed for the tungstates (chapter III), two for silver and copper activated sulphides (chapter IV), two and three for manganese activated zinc silicate and zinc beryllium silicate respectively (chapter V), whereas the halophosphates (chapter VI) needed three of these functions.

From the measured temperature dependence of the parameters of the Gauss functions follows:

1. The half intensity breadths and the peak wave numbers can be described by linear functions of temperature, with the exception of the region of the very low temperatures (0 = 1000K).
2. The half intensity breadth always increases linearly with temperature; the wave number of the peak, however, sometimes increases linearly with temperature (tungstates, halophosphates), sometimes remains nearly constant (willemite), or decreases with temperature \((Zn, Be)_2SiO_4 : In^+_1\).
3. Since the total intensity of the band is proportional to the product of the half intensity breadth \( H(T) \) and the peak intensity \( A(T) \), this total intensity can be determined in a simple way from a measurement of \( A(T) \), the \( H(T) \) being determined in the analysis.
The analysis of the emission spectra, measured at different temperatures, allows to gain insight into the mechanism of luminescence. Examples are given in chapter IV, where it is shown that the same bands are emitted, though in different intensity ratios, when a ZnS:Cu phosphor is excited by photons and cathode rays respectively and in chapter V, where the analysis of the emission bands of willemite (0.1% Mn) shows that energy transfer occurs between both the excited states of the luminescent centre, which can be reasonably described with the aid of the theory.

Investigating the cathodo-luminescence of ZnS:Cu, also the loss in efficiency of the emitting layer was investigated as a function of the energy input (chapter IV). The dependence of the emission spectrum on the grain size of ZnS:Ag was also determined; the spectra of particles with mean grain sizes of 12 and 40 µ showed no difference; accordingly an equal perfection of the lattice of both fractions has to be assumed (chapter IV).

In chapter VII has been examined which shape has to be expected for a single emission band from a calculation on the basis of the zone model and the configuration coordinate model respectively. Taking the configuration coordinate model as a starting-point, an approximative treatment shows that, at each temperature of the emitting phosphor layer, the shape of a single emission band is Gaussian. The relations derived in this treatment for the half intensity breadth and the peak wave number as functions of the temperature are generally in good agreement with the experiment.

From the experimental data a few characteristic constants have been determined for the configuration coordinate model. From the same model the emission curve of CaWO₄:Pb was computed in a more rigorous way; the agreement with the experiment is reasonable.

Taking into account the anharmonicity of the oscillators of the configuration coordinate model, the theoretical results may be improved.