greater mobility and interaction of physicists throughout Europe. Most of these require action by the Society as a whole, but ACAPPI has pursued the first two in particular. The Committee believes that without effective and demonstrably relevant activity on such matters, applied physicists will not become really active in the Society ; exhortations alone do not succeed.

Finally, it should be recorded that this is a personal statement by the retiring Chairman of ACAPPI. The incoming Chairman, J.-P. Hurault, and his fellow-members will steer their own course, but undoubtedly their objective will be the same : to ensure that EPS becomes as much the home for the applied physicist as it already is for his more fundamental colleagues. Success in this aim is surely a major challenge to the EPS at this time.

L.A.A. Thomas

Luminescence Processes in Phosphors for Cathode-Ray Tubes and Lamps

An ACAPPI — CMD Europhysics Study Conference

At the end of March scientists from ten European countries, from Israel and the USA met at the National College of Food Technology, Weybridge in England for a three-day Europhysics Study Conference on « Luminescence Processes in Phosphors for Cathode-Ray Tubes and Lamps ». This conference was organised within the EPS by ACAPPI and the Condensed Matter Division, the theme reflecting the Committee's view that the technologically important field of phosphor research is not one which is well served by conferences, particularly within Europe. It is also a field where a fundamental understanding of the basic materials physics is not yet well developed, and the opportunity for an interdisciplinary forum along the lines of the Gordon Research Conferences was especially welcome to many people. Of the 84 participants, 48 were from industrial laboratories, 26 from universities and related institutions and 10 from government research establishments.

The Conference comprised seven sessions, the theme of each being set by a one hour introductory lecture from the session chairman. This invited contribution was followed in each case by a small number of short submitted papers and finally by a substantial discussion period. The majority of sessions were designed to highlight particular aspects of phosphor operation, where present theoretical understanding is limited. Nowhere was this emphasis better illustrated than in the opening session on saturation effects in CRT phosphors led jointly by the Programme Chairman P. J. Dean and G. O. Muller. Saturation in II - VI phosphors can be reasonably explained by the low activator concentration producing optimum performance in these materials, but in high concentration ($\sim 1\ \%$) RE phosphors a different explanation is necessary. A possible cause of saturation in RE materials is beam-induced heating, but recent work using materials with an internal "spectroscopic thermometer" in order to measure instantaneous temperature during the luminescence process, indicates that this is not the dominant factor at moderate drive levels in a CRT. There is some suggestion that the saturation may, at least partly, be the result of luminescence quenching through space-charge electric fields generated by the incident electron beam. At the end of the introductory talk, Dean reviewed work on electric field effects on luminescence in semiconductors, and emphasised the importance of surface properties in controlling some of these field effects. The effects of phosphor surfaces on their performance was a theme taken up in a later session chaired by R.-H. Williams. Intuitively, one would believe that surface effects must be important in phosphors, which have a relatively large surface/volume ratio compared with most electronic materials, and yet the paucity of work in this area was immediately apparent. As the speaker suggested, this is an area ripe for development. However the difficulties should not be discounted, and in reviewing the properties of surface states and the commonly-used experimental techniques, Williams emphasised that a multi-technique investigation on both powder and single crystal material simultaneously, would be necessary to identify convincingly the relationship between surface properties and luminescence efficiency in phospor materials. Further progress in this area seems to depend upon the identification of suitable systems for study, and these unfortunately did not emerge at the Conference. Perhaps the answer is to be found amongst those materials of immediate technological interest as low-energy CRT phosphors, where surface effects are of paramount importance.

There were two sessions devoted to energy absorption, diffusion and loca-

lisation effects in phosphors. In the first A.L.N. Stevels discussed the relationship between lattice structure and photon absorption processes in lamp phosphors activated by different impurities. It is clear that our understanding of energy absorption and conversion processes becomes progressively worse as the excitation energy increases. Where absorption into a spatially-localised state of the phosphor activator occurs, the spectroscopy is relatively well-developed, even when energy migration amongst the activator centres is possible. For excitation energies above the absorption edge of the host lattice however, spatially-delocalised states are created and energy diffusion occurs prior to localisation. With high energy ionising radiation there are secondary multiplication processes important in determining the energy conversion efficiency, but the physical details remain a mystery. Correlations between luminescence efficiency and lattice band gap or plasmon frequency successfully applied in semiconductor materials, appear much less satisfactory for phosphors.

Some concepts involved in building models of energy conversion and energy transfer processes in phosphors were explored in the session chaired by the present author. There are some solid state luminescent systems, including organic crystals, semiconductor l.e.d.s and the alkali halide scintillators, in which models for lattice-to-impurity energy transfer are quite well developed, and these were reviewed. Common principles emerged from this review which were applied in the interpretation of recent work by the author on RE-activated garnet phosphors, and led to a simple model which relates the energy transfer probability to the nature of the electronic states of the activator near the absorption edge. In this rather difficult area of energy diffusion and localisation in phosphors, useful insight can emerge from a careful study of work in related fields, particularly semiconductors, where the theoretical understanding is more firmly based. While phosphors and semiconductors cannot be equated there are sufficient points of common principle to show the value of critical comparisons.

There was a session chaired jointly by G. Blasse and R. Englman concerned with the final stage in the phosphor mechanism, the radiative and non-radiative processes occuring at an excited activator centre. Blasse reviewed current theories of multiphonon relaxation, contrasting the widely-used single configuration coordinate (SCC) model with the complex analytical formulae which result when the total phonon density of states is included in the theory. On a semi-empirical basis it was suggested that efficient phosphor lattices should be "stiff", allowing only small Stoke's Shift, and should not introduce a charge transfer state at low energy which could cause significant thermal quenching of luminescence at room temperature. Englman continued the theoretical development, emphasising the distinction between modes which mix electronic states in a relaxation process and those which serve to dissipate the excess energy, and during the discussion period it emerged that anharmonic effects were probably not so significant as recently suggested. Non-radiative processes are often essential in phosphor operation, as in upconverter materials, and their importance should not be underestimated. The SCC model was discussed in detail by C. W. Struck in a contributed paper, and for all its limitations, the conceptual simplicity of this model makes it still the most attractive for the experimentalist in the interpretation of his data.

In an evening session A. Bril reviewed the current state of the art in X-ray screens and image intensifiers. The quantum detection efficiency of the RE-activated screens is considerably higher than that of the standard $CaWO_4$ screens, but the thickness of screen ($\sim$200μm) required with powder materials still limits the resolution of the image. The situation can be improved using evaporated films which have a higher density than powder screens, and there is much current interest in CsI : Na for this purpose. However the nature of the emitting centre in this material is still not clear.

Participants' reactions to the Conference as a whole were mixed. Physicists not specialising in the phosphor field found the emphasis on fundamentals useful and stimulating since it highlighted principles common to other types of material, particularly semiconductors. In this sense the Conference served to bridge a communications gap between scientists devoted to a better understanding of the physics of luminescent materials. Those phosphor chemists interested primarily in the practical preparation of phosphor materials were generally less happy with the format and possibly felt that there is still too wide a gulf between theory and practice. In the author's view however the longer term benefits accruing from an improved understanding of basic mechanisms should be two-fold. First, a theoretical model can be used to guide development work, which will become increasingly important as user requirements become more specialised, and secondly it should be possible to predict theoretical maximum efficiencies for different phosphors so that the progress of development can be monitored. It may seem unfortunate, but it is probably true, that an understanding of relatively complex defined materials will only emerge as a projection from work on simpler but better defined materials ; the practical chemist must therefore be patient and allow the fundamentalist some freedom in his choice of material for study so that the problems remain tractable at each stage.

This Conference has asked some first faltering questions in the phosphor field, particularly with regard to the significance of surface effects and the best approach towards a model for energy diffusion and localisation processes in phosphors. Let us hope the posing of these questions may produce a further welcome injection of science into an area where many people feel mysticism and magic still prevail.

D.J. Robbins

7th International Conference on High-Energy Physics and Nuclear Structure

(sponsored by IUPAP)

to be held in **Zürich from August 29 through September 2, 1977**
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