Young Scientist

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"C'était très bien, je vous félicite!" said a man when I returned to my seat in the conference hall at Asia Display '95, held in Hamamatsu, Japan.

When I joined Toshiba, it had already been decided that my work would be on the development of 'spherical phosphors'. My boss, Dr Masaaki Tamatani, a researcher with more than 20 years of experience in the phosphor field, had created these beautiful pearl shaped phosphors (see the photograph) a few months before, and decided to develop them for practical use. My work on spherical phosphors covered a wide range of activities, including preparation of the raw materials, their spheroidization and subsequent evaluation, phosphor screen preparation and simulation calculations.

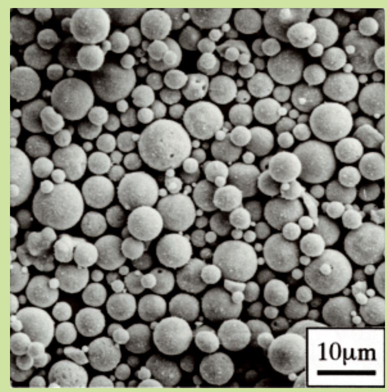
At first, we spheroidized several phosphor materials by the thermal plasma method.(1)(2) In this method, the phosphor particles, put in a plasma flame whose temperature is several thousand degrees, melt and solidify into a spherical shape due to the surface tension. Because a part of some particular elements of the material evaporated during this process, every phosphor acquired a body color, and XRD measurements revealed that their stoichiometry had been distorted. As a result, their brightness decreased to half or less of the original material — a critical problem for a phosphor. This problem occurred even for the red-emitting europium doped yttrium oxide (Y_2O_3:Eu) phosphor, which had the simplest composition. However, by eliminating impurities in the raw material and by optimizing the plasma conditions in cooperation with Neturen Co., Ltd., a thermal plasma equipment manufacturer, the evaporation and the body coloring could be suppressed. Moreover, by doing an annealing after the spheroidization, we were able to obtain a spherical Y_2O_3:Eu phosphor suitable for commercialization.

For phosphors to be used as a layer, their layer properties are very important. Because of the spherical shape and the good dispersion of each particle, spherical phosphors are expected to produce a thin, highly dense and uniform layer. In practice, we could decrease the thickness of a phosphor layer composed of spherical phosphors by 30%, compared with a layer made of conventional phosphors having the same coating weight. In addition, because of the good transparency of the spherical particles, the light coming out of the phosphor layer should have a minimal loss. Therefore, we attempted to manufacture projection CRTs using spherical phosphors.

A projection CRT is a small-sized monochrome CRT used for projection TVs. Images obtained from red-, green- and blue-emitting CRTs are enlarged with lenses and projected on a screen measuring over 40 inches in diagonal. Thus, resolution and brightness are crucial for projection CRTs. We found, with the participation of Toshiba Hokuto Electronics Corp., a projection CRT manufacturer, that both characteristics could be increased by 10% by using spherical phosphors. These data were sufficiently convincing that we decided to present spherical phosphors to the world.

Eventually the day came for me to introduce spherical phosphors for the first time to the public at Asia Display '95.(3) This was also my first oral presentation in an international conference, and I must have looked so nervous that the man, an ex-colleague of my father, praised me. I was not expecting to hear French in Japan and was very surprised to meet someone who knew me, but I was so glad to be honored like this when I needed confidence in myself. As he told me, 'spherical phosphors' were certainly a success and created a great sensation. Several companies called us later to obtain information, and some phosphor research groups, from Japan and overseas, went on to produce spherical phosphors by various techniques. Additionally, one year later, our phosphor research group received the 'Phosphor Award 1996' from the Phosphor Research Society.

The next stage of my work was to create spherical phosphors emitting colors other than red. Because the green-emitting phosphor makes a major contribution to the brightness of projection TVs, we tried to spheroidize green-emitting terbium doped yttrium silicate (Y_2SiO_5:Tb) phosphor. However, because of its complex stoichiometry, we encountered more serious problems than in the case of Y_2O_3:Eu. By solving these problems one by one, we finally succeeded in obtaining a practical spherical Y_2SiO_5:Tb phosphor.



Once we obtained the required spherical phosphors, we had to optimize the layer characteristics of the CRTs. Because projection CRTs need a higher resolution (reflecting the recent increasing demand for high-definition TVs), we calculated the trajectory of the light in the phosphor screen, with the aid of a Monte-Carlo simulation, to evaluate the resolution.(4) The electron beam reaching the phosphor particles is converted into visible light, which spreads out in the phosphor screen due to scattering. Thus, the width of the output light (called 'spot size' and represents the resolution) becomes larger than that of the electron beam. Since the layer using spherical phosphors is thinner, the width of the spot size becomes smaller than that of a thicker layer. Unfortunately, while the light scattering length of spherical phosphors is larger than that of the conventional phosphors (because of the smaller surface area of the particles), light spreads further along the lateral direction, which leads to a larger spot size and cancels the effect of the layer thickness. From the calculations, we found that by decreasing the phosphor secondary particle size by 20%, effect of the light scattering length and that of the layer thickness can be minimized and maximized, respectively. As a result, projection CRTs with improved resolution were obtained. To perform this work, we collaborated with two French students who worked as trainees in our research group — that was a very pleasant experience for me, because it gave me the opportunity to be in contact with French people and culture.

Five years after the spherical phosphors were first made known to the public, Toshiba started to use spherical Y_2O_3:Eu and Y_2SiO_5:Tb phosphors in its 2000 model projection CRTs.(5) Thanks to the spherical phosphors and a newly developed electron gun, the resolution of the 2001 model projection CRTs increased by 40% over that of the conventional 1999 model, and the market share of Toshiba is growing.

Spherical phosphors are also expected to show good characteristics in other light-emitting devices, such as PDPs (Plasma Display Panels), FEDs (Field Emission Displays), fluorescent lamps, X-ray detectors, etc. Because each device uses its own particular phosphors, the development of other spherical phosphors will be difficult and time-consuming, but very interesting for the future of luminescent devices.

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References

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Present Status of JJAP and IPAP

The Japanese Journal of Applied Physics (JJAP) aims to disseminate in English original and up-to-date results of cutting-edge R&D in broad technical areas related to applied physics. JJAP, now 40 years-old, contains more than 2,000 papers per year and is distributed in more than 50 countries worldwide. It is recognized as an indispensable source of technical information in such wide areas as semiconductor devices and processing technologies, blue lasers, magnetic and optical storage, liquid crystals, ceramics, and high-temperature superconductors, to name but a few. JJAP is a MUST for technology-conscious libraries and individuals. Online services of the Journal provide extensive coverage, and a web-based reviewing system has recently been introduced to accelerate even more the already speedy editorial and peer-review processes.

Since April 2000, JJAP has been published for JSAP through the Institute of Pure and Applied Physics (IPAP). IPAP was established jointly by JSAP and the Physical Society of Japan (JPS) to publish four journals in English owned by both societies including JJAP and the Optical Review with special emphasis on the promotion of electronic publishing.

Such activities and the current status of JJAP and IPAP, etc. were explained in detail by Professor Kunio Tada, former president of IPAP, at the 2nd ICSU-UNESCO International Conference on Electronic Publishing in Science held on February 20-23, 2001 in Paris. The conference proceedings have recently been published online only at http://associnst.ox.ac.uk/~icsuinfo/proc01fin.htm They contain the full paper by Professor Tada, "The role of non-profit organizations such as learned societies in Japan", which was presented in Session IV on February 20.

For other information about JJAP and IPAP, please visit http://www.ipap.jp for details.

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