9-3: CCFL BACKLIGHT CHARACTERIZATION USING LUMINANCE METER AND IMAGE ANALYSIS.

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Abstract:

In this article, we present a method to measure precisely the performances of direct-lit CCFL backlights using a luminance meter and dedicated image analysis software. The array of CCFL tubes alone can be measured directly and the luminance of each tube can be extracted along its main dimension. So, comparison of the different tubes on the same backlight can be made easily and the performances in terms of backlight uniformity improved. The influence of the diffuser sheet can be probed in the same way and the homogeneity of the entire surface of the backlight can be automatically extracted and quantified.

Introduction

Development of LCD television has increased the requirements on backlights in terms of brightness and homogeneity. Indeed current high resolution large viewing angle LCDs transmit as little as 3%. So, backlights have important brightness issues to compete with CRTs on TV market. A lot of effort are currently made on both the emitting and their optical and mechanical arrangement (diffusing films, reflector), in order to increase the mean brightness of the backlight while kipping good homogeneity performances. In the same time, more and more care is devoted to MURA defect on LCD.

Three backlight technologies are widely used for the LCD: cold cathode fluorescent lamps (CCFL) -and its daughter technology EEFL (external electrode fluorescent Lamp)-, the EL and the LED modules. We can also mention the currently anecdotic planon solution [1] that may thrust in the next future. EL are widely used because they are extremely thin, of low cost and provide a cold and uniform light. However they are very sensitive to humidity and suffer from a weak intensity and a short life cycle. LEDs are most widely used in cellular phones and provide a higher brightness and life time. Moreover they don't require the use of inverters. CCFLs are the most common light source in Laptop displays. It provides a uniform and bright white light for a typical life of about 30 000 Hrs. Except for price concern, it's currently the prime choice technology for displays backlighting. However CCFLs still suffer from important drawbacks: Because CCFLs are fluorescent tubes, they have limitations in temperature. Under low temperatures CCFLs suffer from flicker and are less intensive, whereas high temperatures shorten tube life. This sensitivity often makes it difficult to use into outdoor and automotive applications. The high dependence of luminance from temperature and age parameters is an important issue of CCFL: The older they are and less bright they become because of Hg consumption. Moreover the working temperature is of highest influence on CCFL performance and aging. Such dependence may lead to different individual aging of each CCFL lamp from a backlight because of the non uniformity of temperature inside the backlight. The final effect is aging dependent non uniformities on the backlight.

That's why it is important to propose efficient solution for R&D department of CCFL makers so that they can quantify the quality of their CCFL (facing environmental conditions, warming time and aging) and improve their process. Furthermore, uniformity is a high challenge for CCFL : since 20 to 30 tubes of small diameter (3mm) are rowed up in the backlight, a need of high uniformity -along CCFL and between CCFLs- is required. A quantification of CCFL uniformity that assess on its quality is useful to ease dialog between CCFL and backlight makers. That's why uniformity tests at quality control are useful as well. Most of CCFL makers that perform such kind of tests generally use a 1D-luminance meter with a scanning method that is more or less accurate (depending on CCFL adjustment facing the scanning axis) and time consuming.

In the following paper, we explain how to use our luminance meter MURATest and CCFL dedicated software to check the performances of the backlights at different stages of their completion. This approach allows checking separately the influence of the different components making the optimization easier for the manufacturer.

CCFL solution

ELDIM's solution for CCFL makers allow them to supervise and quantify the luminance uniformity along each tube and inter tubes. The sensor used to make such a control is a 2D luminance meter: the MURATest from ELDIM. Direct measurements of the backlights are obtained that lead to acquisitions like figure 1 and 5, since our solution allow uniformity measurement before (on naked tubes) and after integration as a backlight (with Diffuser plate and sheet, BEF and DBEF).

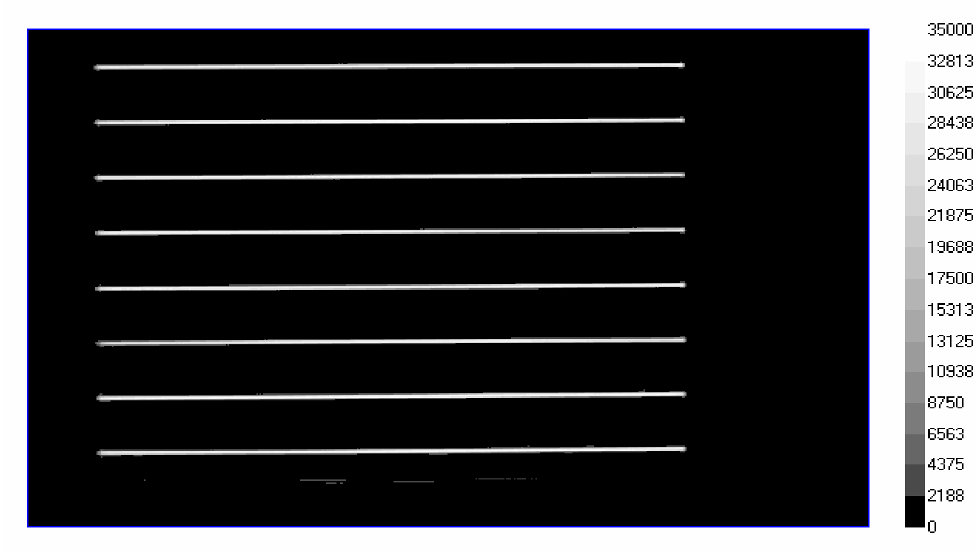

*Figure 1: **Image of a CCFL backlight with 8 CCFL***

The MURATest is equipped with a telecentric objective with low distortion which allows fields of view up to ±16°. The optical sensor is a high resolution CCD cooled down to -30°C with custom design filters and sensor calibration. Each equipment having its own sets of color filter to perfectly match the CIE curves allows high accuracy luminance and color measurements. The telecentric-on-lense design ensures a very high luminance accuracy uniform on the whole map. Luminance range between 0.1 and 10 000 Cd/m2 can be measured with an accuracy of ±3% and a short term repeatability of ±0.5%. You can find further details about this equipment in [3].

CCFL dedicated .NET software then allows acquiring the image of the CCFLs and extracting luminance information along each tube (averaging data on its width). An excel report is provided showing profiles of intensities on a joint chart (see figure 2).

Measurement on naked tubes

CCFL Tubes:

The common approach for CCFL backlighting is a direct lit configuration with an array of CCFL tubes placed directly behind the LCD. In order to achieve an acceptable level of brightness, the tubes are placed together every 10 to 50 mm. Direct imaging of the tubes alone without any diffuser or LC Cell can be used to check the quality of the tubes. Such a measurement is reported in figure 1.

Analysis Task

We have developed automated software that analyzes the image to found the different tubes and to integrate the luminance of each tube. A custom number of channels can be defined in the transverse direction. The analysis results of the measurement of figure 1 are reported in figure 2 and 3.

Results

The luminance clearly depends varies along each tube in a quite important way. Moreover the average luminance varies significantly form one tube to the other. In figure 2 the average luminance varies from 27 500 cda/m² for tube 3 to 31500 cda/m² for tube 1. This represents a 13% variation that may induce important lack of uniformity for the final backlight. This analysis is useful to adjust the power supply and the regulation of the tubes. The same kind of measurement repeated in time can allow evaluating warming time effects for short term and aging effects on CCFL for long term.

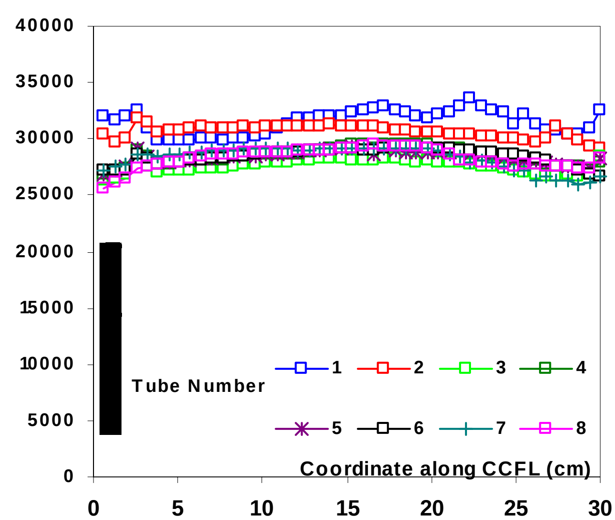

***Figure 2**: Luminance of the different tubes versus length (from figure 1).*

We have seen that non uniformity inter- tubes can be very intensive. Even in a smaller extent, non uniformity inside each CCFL can be intensive as well, whereas obviously unwanted.

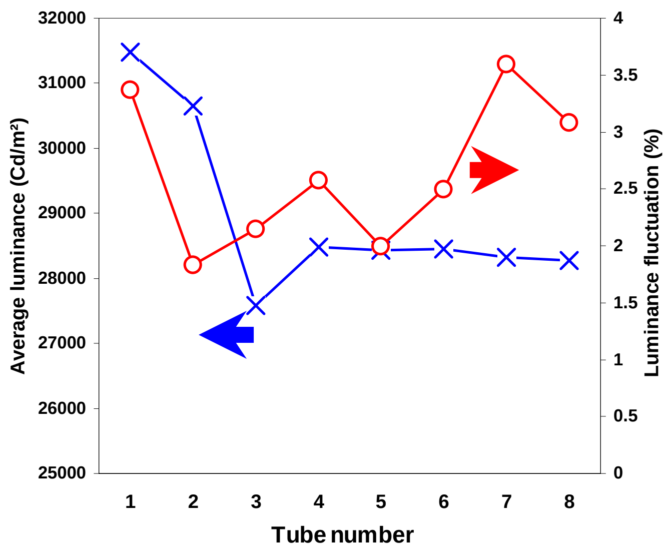

***Figure 3**: Average luminance on tube and luminance fluctuations (from figure 1).*

In the above example (fig 3), variations can reach up 2 to 4% along one given tube. The following diagram shows on the (x) curve the average intensity for each tube, and on the (o) curve the standard deviation of intensity on each tube (in % of average value). The performances can also be followed after switching on the system.

Measurement on integrated tubes

Optical diffuser sheets:

To improve the uniformity of direct-lit backlighting, optical diffuser sheets are used between the lamps and the LCD. Their aim is to reduce the direct transmission of the lamps through the LCD and increase the secondary reflections. Then secondary films named BEF (brightness enhancement films) are added.

Assembly of such layers may lead to new uniformity defects. A second complementary way of evaluating uniformity of backlight consists then, with the same equipment, in acquiring an image of the complete backlight. Then dedicated software can quantify large area variations (due to CCFL geometry as well as film design) and find local defects due to local scratches in films.

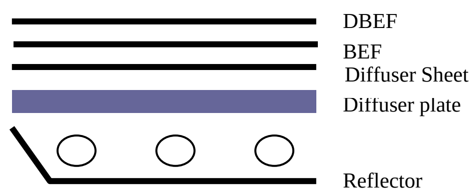

***Figure 4**: CCFL direct-lit structure*

***Figure 5**: Image of the CCFL backlight of figure 1 with the diffuser sheet.*

The complete backlight can be evaluated using our luminance meter in the same way as previously. One example corresponding to the CCFL tubes of figure 1 with an additional diffuser sheet is reported in figure 5. From this image, the luminance distribution can be extracted precisely. The histogram of this distribution is reported in figure 6. The average value and the standard deviation are important quantitative parameters for the backlight performances. Furthermore the complete histogram provides more information, like the maximum deviation from average, the complete range of variation for the backlight (which is very important), the possible occurrence of multiple picks when facing CCFL with very different intensities.

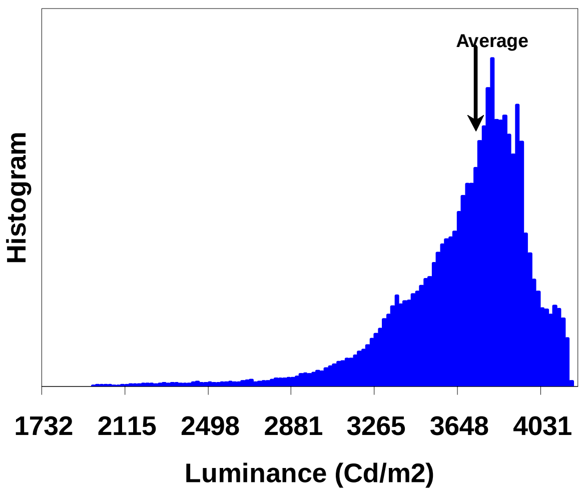

Figure 6*: Histogram: Luminance distribution from figure 4.*

A second kind of information concerns the geometry of the distribution. One way to evaluate this kind of effect and more important to be able to compare different configurations is to apply a MURA defect analysis on this kind of acquisition. Such Software and quantification are based on a SEMI standard and extracted from the LCD QC final tests needs. You can find further information about such tests in [2-4].

We have been working for years on this kind of analysis for the final test of the displays [3], and commercial analysis software is already available at ELDIM. Applied to the backlight analysis, it can be used to give a quantified degree to the geometrical distribution of luminance within the surface of the backlight. For example in figure 6, a simple MURA analysis of figure 4 shows the reduction of light on the borders of the backlight and propose a quantification of such a defect. The quantification depends on surface of the defect as well as on its contrast. A simple critical level can lead to pass/fail agreement about the uniformity of the backlight.

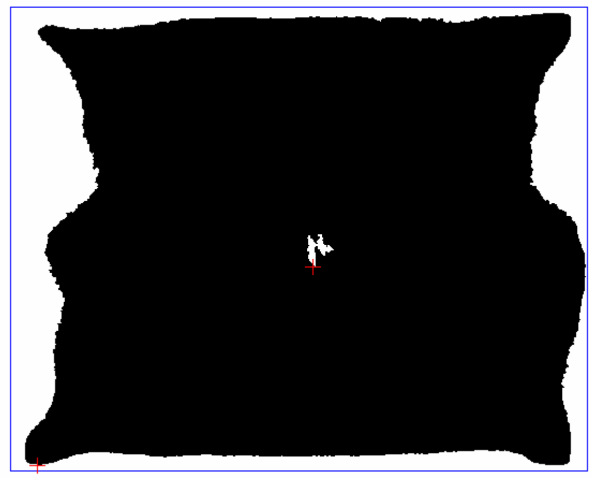

Figure 7*: MURA analysis of the image of figure 4. The importance of the border and central defects can be precisely evaluated*

Conclusions

We have presented a method to measure precisely the performances of direct-lit CCFL backlights using a 2D-luminance meter and especially devoted image analysis software. The performances of the different CCFL tubes can be extracted independently to make the optimization of the system easier. The effect of the diffuser sheet can also be measured directly and quantitative information of the luminance distribution can be extracted using MURA defect analysis. The paper will present more experimental results in various experimental configurations.

References

[1] « a 32-in. Integrated Hg-free Lamp that eliminates problems of backlights with multiple lamp », L. Hitzsche, F.VollKommer, K.D. Bauer, OSRAM Gmbh, SID04

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[4] SEMI D31-1102 : Definition of measurement index (SEMU) for luminance MURA in FPD image quality inspection.