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Laser TV

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Abstract: **We have developed an HDTV that adopts semiconductor lasers involving three primary colors, red, green and blue for the light source. The adoption of a laser light source helped us realize a HDTV with a dramatically wide color gamut, namely 190% the color gamut of ITR-U BT.709. In addition, we have also developed an LSI that can deal with an extended color space xv YCC, which is a new international standard, and mounted the LSI in the HDTV. The display of colorful and natural video pictures has been achieved through the effective use of the wide color gamut involved in the laser light source supported by a video signal processing circuit that complies with the xv YCC standard and Natural Color Matrix, a color management.**

Keywords: **HDTV, Laser TV.**

1. INTRODUCTION

As the multimedia society has come, the need for large area display is increasing more rapidly. So many kinds of projection displays are now developed and are developing, such as LCD, DMD, LCOS and so on. Most projection displays are now using the lamp as a light source, so the effort for using the laser as a light source is continued for its merits of laser1, 2. The advantages of using the laser light for projection displays are come from the original characteristics of laser. The main advantages of scanning laser projection displays are high contrast ratio, excellent expression of natural color and infinite depth of focus. Laser light is polarized, so it can yield a higher contrast ratio by using the proper polarized optics. The monochromatic property and color saturation of the laser light can increase the color space about three times larger than that of the conventional phosphor system3, 4. The wavelengths of lasers cover more than 90% of all colors which can be perceived by the human eye.

2. BACKGROUND OF LASER TELEVISION DEVELOPMENT

We have commercialized the world’s first laser television system using a three primary color laser light source. This television features double the color reproduction gamut and high contrast ratio compared to conventional LCD televisions. Through this laser television system, we propose a new type of large-screen television with super-high resolution and innovative compact design. The demand for large-screen televisions has been growing as high-vision broadcasting featuring high-definition images becomes increasingly popular .Moreover, since viewers tend to prefer to watch a large-screen television, the demand for large-screen, high-quality-image televisions with high definition and wide color reproduction gamut has been growing. Mean while, work on the worldwide standardization of extended color space, the color space that can render a wide color gamut, has been under way (1) (2). The extended color space xv YCC, which is the standard for motion pictures, was internationally standardized in January 2006. Display devices have also been supporting wide-gamut color reproduction (3).

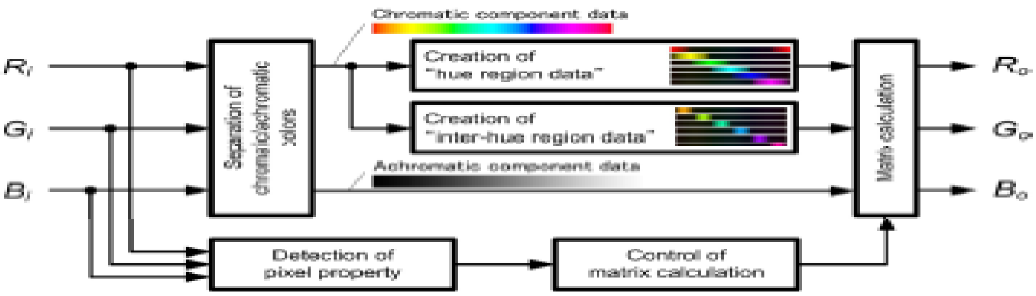

Figure 1: xvYCC standard compatible NCM

3. FEATURES OF LASER TELEVISIONS

Our laser television realizes an extremely wide color reproduction gamut which is double that of traditional LCD televisions by employing a three primary color laser light source. This wide color reproduction gamut produces vivid images which could not be displayed in the past .The laser television incorporates a newly developed laser light source, super wide-angle optical engine dedicated to the laser with far smaller optical system thanks to its smaller diameter by taking advantage of the laser light with small divergence angle, thin screen, small case, and compact laser driving power supply. Thanks to the design with these compact components, the laser can be hung against a wall. Moreover, since the laser light source with high luminous efficiency is optimally driven with the lighting control circuit, the power consumption is as low as 135 W, one-third that of a conventional LCD television, even though the screen size is large. This television includes 3D video display function, enabling both normal broadcasting and 3D images to be shown on one laser television. By wearing dedicated glasses, multiple viewers can enjoy dynamic 3D images with high color reproduction on the wide screen at the same time.

4. DEVELOPMENT OF LASER TELEVISION

We started developing laser televisions in earnest in 2005. After prototyping 52-inch and 56-inch televisions, we then developed and marketed 65-inch laser televisions (4) to (6). Table 1 lists the specifications of laser televisions that have been developed. The 52-inch prototype television developed in 2006 was used to study color reproduction gamut of the laser light source and color rendering methods as a basic verification of the optics of laser light image rendering. The 56-inch prototype television developed in 2007 was used for verification of thinner product designs. Since both prototypes were intended as fundamental prototypes, the optical engine was installed in the television case, but the laser light source, laser light source driving circuit, and video signal processing circuit were stored in the table on which the television rests. The laser light source and optical engine were connected through optical fiber cables .The laser television developed and marketed this time contains all components within the case with a depth of 269 mm

Table 1: Specification of laser TV

	208 LaserVue	2007 prototype	2006 prototype
Screen size (inches)	**65**	**56**	**52**
Laser power(cd/m2)	**500**	**500**	**500**
Lawser power(W)	**19.4**	**19.6**	**18**
Dimensions(H*W*D) (mm)	**1011*1466*269**	**918*1208*263**	**864*1260*473**
Color gamut on uv(%) (vs ITU-RBT-709)	**208%**	**182%**	**179%**

5. LASER TV

Figure 1 shows a schematic drawing of the basic layout of the laser TV. It is mainly composed of blue, green and red laser light sources, three acousto-optic modulators, a laser beam combining part (a high-reflection mirror and two dichroic mirrors), a polygon scan mirror, a galvanometer and optical lenses.

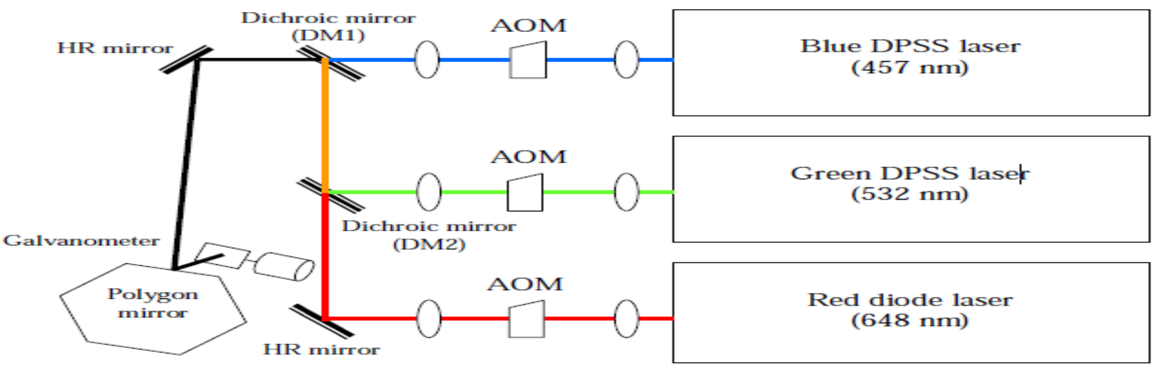

Figure 2: Schematic drawing of the basic layout of the laser TV.

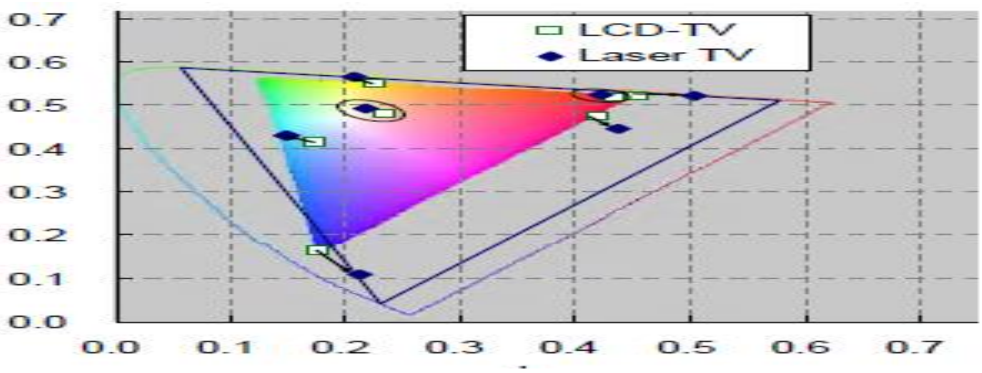

Figure 3: Colour reproduction of laser TV

Blue, green diode-pumped solid state (DPSS) lasers and a red diode laser are used as a light source. The wavelengths of the blue ,green and red are 457 nm, 532 nm and 648 nm, and the output powers are 350 m W, 700 m W and 500 m W, respectively. The power levels of lasers are adjusted for white color balance. Diode-pumped solid state (DPSS) lasers are an exciting tool that combines the beam quality of a gas laser, small size and efficiency of a diode laser with single line output. Blue, green and red laser beams are modulated at acousto-optic modulators (AOMs) according to the video signals. Laser beam modulation in the acousto-optic device is implemented by varying the amplitude of the acoustic drive signal, which in turn varies the amplitude of the light passed to the first order. Separated RGB color signals are amplified by a high frequency signal amplifier and are used in modulating each laser beam by the acousto-optic modulator. Modulated red, green and blue light beams are combined by dichroic mirrors and a high-reflection mirror. Then the combined beam is projected to the screen by the scanning part. The dichroic mirror (DM2) for combining the green light with the red light has a transmittance over 95% in the red light, and a reflectance of 99% in the green light. The dichroic mirror (DM1) for combining the blue light with the green and red light has a transmittance over 95% in the blue light, and a reflectance of 99% in the green and red light. All dichroic mirrors are designed to obtain the best performance with the 45□□incident angle. Combined laser beam is horizontally scanned by a polygon scan mirror and vertically scanned by a galvanometer. The galvanometer is running at a rate of 60 Hz. The polygon scan mirror has 25 facets and is rotating at the speed of 75,600 rpm for VGA resolution (640x480 Progressive scanning). Therefore the scan rate is 31.5 kHz in coinciding

6. BREWSTER-ANGLE TYPE AOM

The acousto-optic modulator (AOM) is fabricated for laser beam modulation. The carrier frequency of the AOM is 350 MHz for XGA resolution. The entrance window is cut at Brewster angle, so the laser beam is incident on the crystal 140 Proc. SPIE Vol. 4657 surface with the Brewster angle. TeO_2 crystal is used as an optical medium and 36□-Y cut $LiNbO_3$ (LN) is attached as a transducer. In case of Brewster-angle type AOM, any optical coating does not needed on the crystal surface, but the transmittance of 99% can be acquired. Modulation performance can simply be characterized by the rise (fall) time, defined as the time interval needed for the output light to grow from 10% to 90% (fall down from 90% to 10%) of its steady state. The rise time of the AOM depends on the diameter of the incident laser beam and the focal length of a focusing lens. The AOM can have faster rise time as the beam waist diameter is narrowed. But focusing the laser beam to improve the rise time degrades the diffraction efficiency of the AOM and makes damages of anti-reflection (AR) coating and the crystal. Brewster-angle type AOM can overcome the laser damage threshold of an optical coating8 and expand it to the crystal damage limit. Figure 3 shows the standard type AOM and the Brewster angle type AOM . Schematic drawings and photographs of (a) standard type AOM and (b) Brewster-angle type AOM. The Brewster-angle type AOM is designed according to the wavelengths of 457 nm, 532 nm and 650 nm.

Table 2: Design specification of the Brewster- angle type AOM

Wavelength(mm)	Refractive index of Teo2	Brewster angle	Thickness of transducer (micro meter)	Electrode size of transducer(mm)	Carrier frequency (MHz)
457	2.5285	68.422	8.6	0.12*2.3	350
532	2.4605	67.882	8.6	0.14*2.0	350
650	2.4065	67.435	8.6	0.16*1.7	350

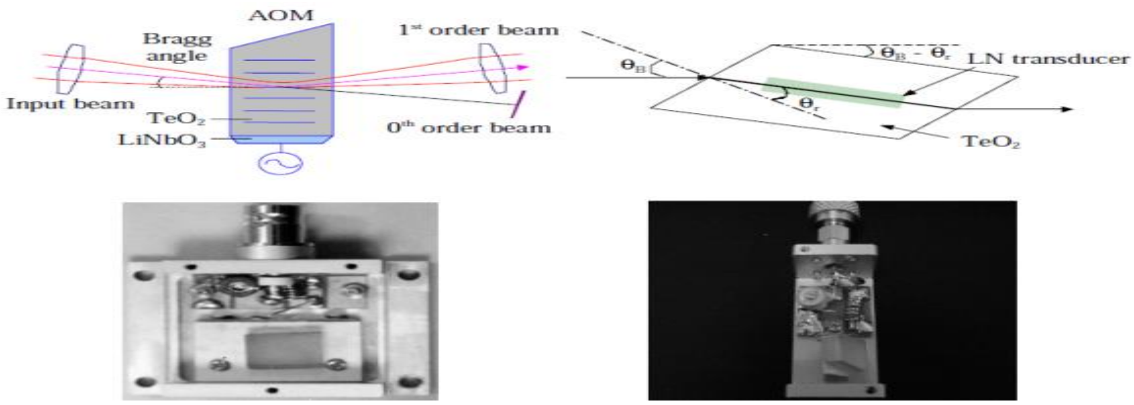

Figure 4: Schematic drawing and photograph (a) standard type AOM and (b) Brewster-angle type AOM

7. CONCLUSION

Color gamut, as large as 190% that of ITR-U BT.709. The use of a laser light source enables the reproduction of a dramatically wide color gamut, but can produce unnatural video pictures with all deep colors. We succeeded in displaying colorful and natural video pictures by correctly controlling colors by means of NCM. We have also developed a signal processing circuit, at the same time, that is compatible with the extended color space called xvYCC, which is a newly defined international standard. The signal processing circuit compatible with the extended color space xvYCC standard and the color management functions of NCM enabled the reproduction of the vivid colors of the xvYCC standard. In the near future, after sufficient dissemination of moving pictures that correspond to the extended color space xvYCC, we will have more opportunities to enjoy video pictures having more impact.

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