Blu-ray Development

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Abstract

Blu-ray research and development have been rigorous from 2002 to the present. The objective of the Blu-ray technology is to upgrade the quality of DVD, thus increasing the capacity of a standard 12 cm optical storage disc about five times that of a DVD. The optical elements as well as materials involved with this technology is very delicate and codependent. However, although all this research has been done, increasing data density is not enough to raise the capacity of a BD to five times the capacity of a DVD. Hence, dual layering is employed and has been done differently than with dual-layered DVDs. BDs use optical properties of the recording material so that one absorbs blue light and the other does not transmit blue light, saving space that BDs do not tolerate. The future for BD lies in speed and consumer practicality.

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1.1 Objective of Blu-ray

Standards for 12-cm optical discs (CD, DVD, Blu-ray Disc) have been set shortly after the development of each type of disc (Fig. 1.1.1). The storage requirement for CDs is 74 minutes of 2-channel audio signals, which comes out to be about 800 MB in capacity. That for DVDs is 135 minutes (most movies fit within this duration) of MPEG-2 compressed video using Standard Definition. This turns out to be 4.7 GB in capacity. Logically, the next technology will bring even higher standards to digital storage discs. Since the establishment of BS and terrestrial digital broadcasting in 2000 and 2003, respectively, movies and television shows are now broadcasted in HDTV (high definition television). To follow that technology, engineers have been developing the Blu-ray Disc. The storage requirement is similar to that of DVDs, two and one-half hours of MPEG-2 compressed video, but using HDTV. This requires a capacity for Blu-ray Discs of 23 GB, roughly five times the capacity of a DVD.

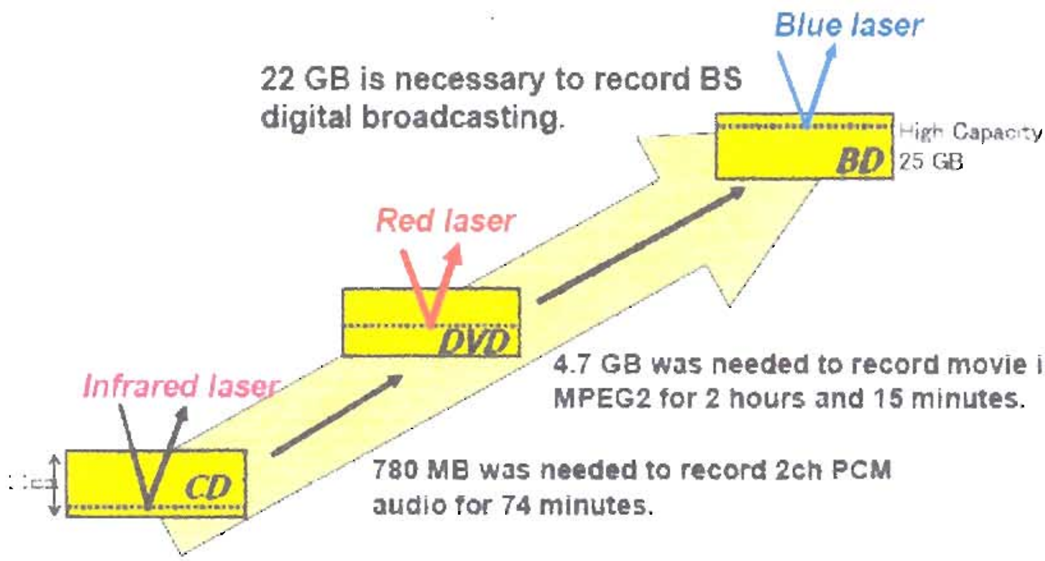

Fig. 1.1.1. Evolution of optical discs

Such a requirement cannot be achieved by increasing disc recording density alone. Engineers have been using techniques such as employing a blue laser, increasing the numerical aperture of the objective lens, adjusting the thickness of the recording substrate to

0.1 mm, and developing aberration compensators. These all contribute to a recording device that have obvious applications, especially in the movie industry.

1.2 Design of Blu-ray System and Disc

1.2.1 "Blu" Laser

The choice of laser for the Blu-ray system was largely limited by the durability transparency of the plastics used in making optical discs.

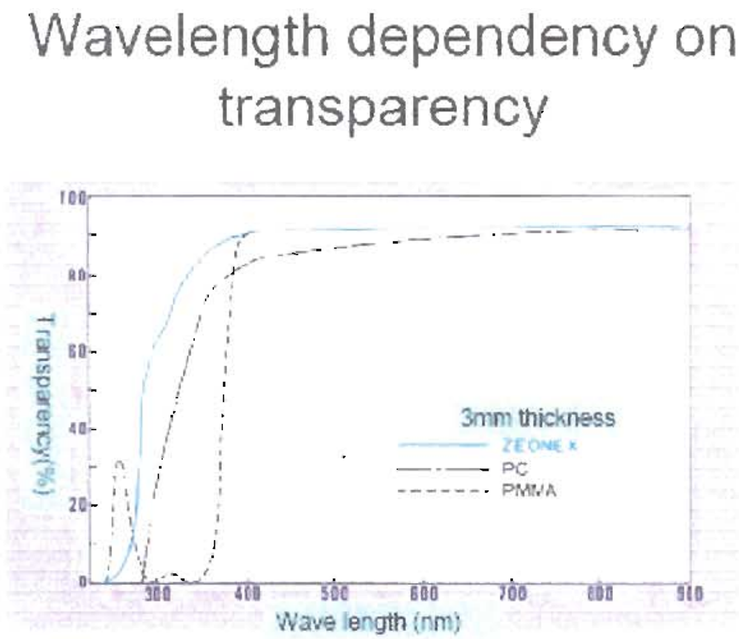

Fig 1.2.1 Durability of plastics

As shown by the figure, the transmission coefficient for the plastics used for optical devices or optical discs suddenly drops when dropping under 400 nm in wavelength. So, the production tolerance is set such that the wavelength for the laser never falls below 400 nm. Typically, wavelength is dependent on temperature, about 0.3 mm/deg for 780 nm (CD) and 025 mm/deg fro 650 nm (DVD). Fortunately, the 400 nm GaN laser (Gallium Nitride Laser) has a very low temperature dependency relative to the 780 nm and 650 nm lasers and can be set to fulfill production tolerance requirements (Fig. 1.2.2).

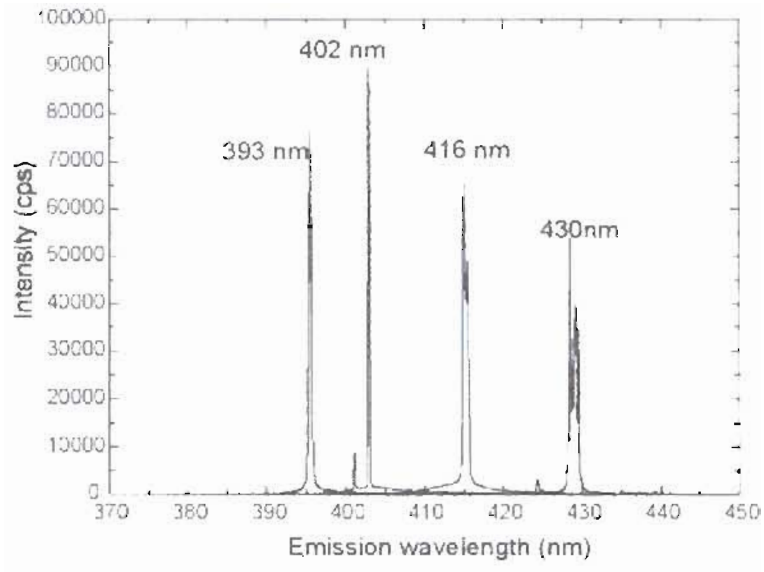

Fig. 1.2.2 Emission spectra for GaN laser diodes at room temperature

The diameter of the beam size of the laser is proportional on the numerical aperture value of the objective lens and is described in the expression:

$d = \alpha * \lambda / NA$; where α is a constant, λ is wavelength.

As seen from the expression, the diameter of the beam decreases as NA increases. The NA value for the production of CDs was 0.45 and that for DVDs was 0.6. The subsequent beam diameters were 2.1 μm and 1.3 μm, respectively. The beam diameter for the developed GaN laser for blu-ray production is 0.58 μm (Fig. 1.2.3).

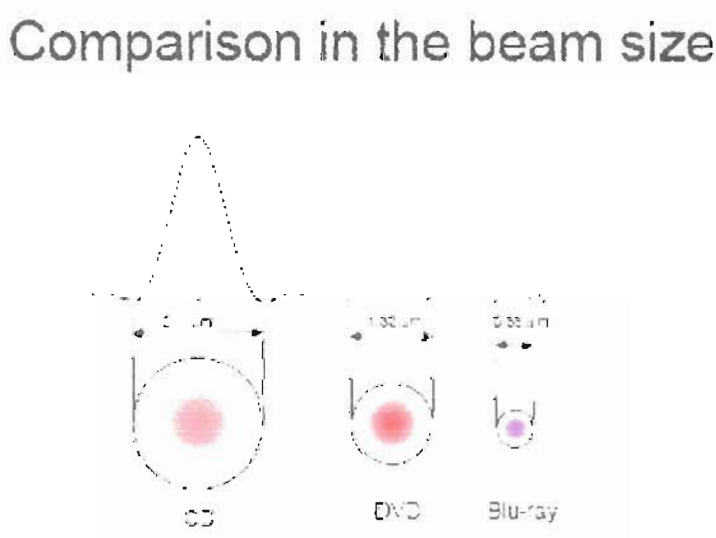

Fig 1.2.3. Beam sizes for optical devices

1.2.2 Focusing Optics

In order to be able to focus the laser to its beam size as mentioned, the NA is set to be 0.85. This is done by laying two lenses on top of one another (Fig. 1.2.4). The resulting working distance is about 0.5 mm, clearing the tolerance to avoid contact between the lens and the disc.

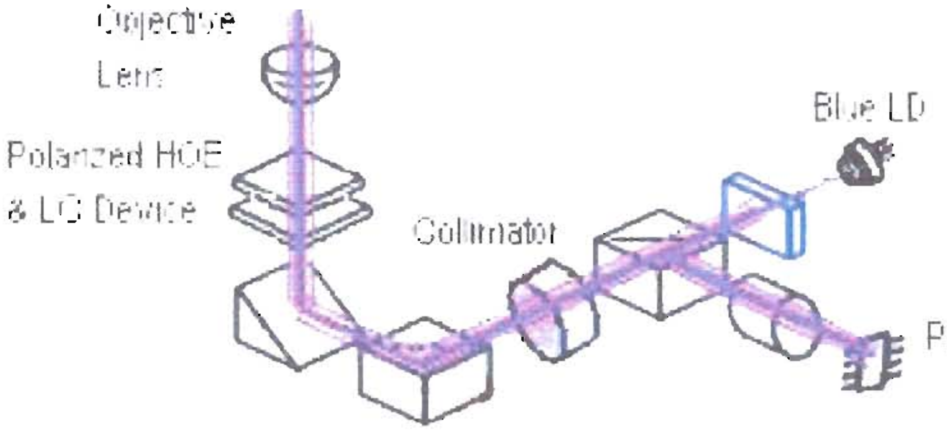

Fig. 1.2.4 Optical elements for Blu-ray system with Polarized HOE (Holographic Optical Element) compatibility

As seen in the figure, the system generally works by first placing a laser through an beam splitter as to give the system an error check method, then collimating the light to various prisms that redirect the light as well as correct aberrations (such as reflection). The beam is then sent through the objective lens where it is focused and is able to burn the disc. In reading the disc, the objective lens takes the reflected light, puts it through back to the beam splitter, which sends the binary data to optical receiver to decode the data.

1.2.3 Disc Components and Materials

The actual Blu-ray disc (BD) itself is conventional. It consists of a plastic or acrylic substrate, such as Zeonex; an aluminum recording layer; a cover layer made of polycarbonate plastic, which lowers the effects of dirt or dust on the disc surface; and a scratch and finger-print-resistant hard coat consisting of a silicon resin.

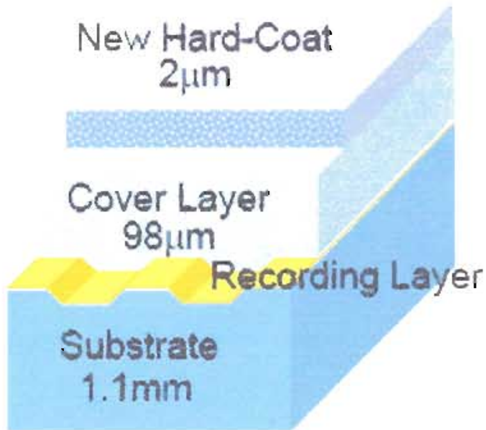

Fig. 1.2.5. Cross section of Blu-ray disc

As specified by the figure, the cover layer is 98 μm. The decision to use this thickness depended greatly on the codependent effects between this cover layer and the objective lens. In order to improve the focusing of the GaN laser and reduce the power needed to record BD, the NA has been raised to a maximum of 0.85. The cover layer, corresponding to this beam size and focal point of the lens (recall that the beam size is dependent on the wavelength and NA of the objective lens) is 98 μm.

1.3 Dual Layer BD

As noted before, a storage capacity of 23 GB cannot be done only by increasing data density on a disc. Even with the all the aberration and focusing adjustments made by engineers, the only method of increasing the capacity to this requirement is by using a dual layer substrate (Fig. 1.3.1).

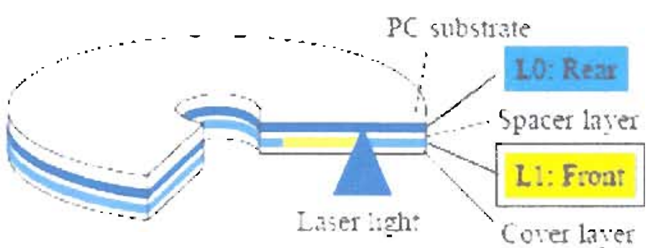

Fig.1.3.1. Dual layer disc

Dual layer is not a completely new technology; presently there are dual-layer DVDs devices available in the market. They are formed by bonding two substrates with a UV resin. These discs are thin enough (0.6 mm) to form a guide groove to record on each layer. However, BD thickness (1.1 mm) is too thick to support a guide groove (Fig. 1.3.2). So, the key is finding materials and specifying the correct thicknesses to work around this problem.

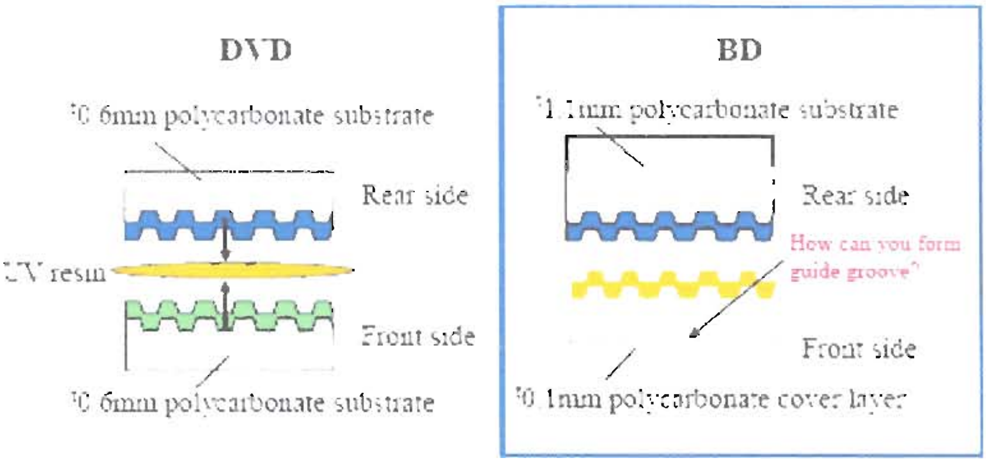

Fig. 1.3.2 Comparison of dual-layer DVD and BD

To solve this problem, the dual-layered BD employs a top recording layer of a silicon or gold layer that absorbs blue light and transmits all other wavelengths and a bottom recording layer that does not reflect blue light. Consequently, the optical receiver in the Blu-ray drive, must be able to distinguish data from blue light from data from other wavelengths. The target is to have the transmittance of both layers to be at 50%.

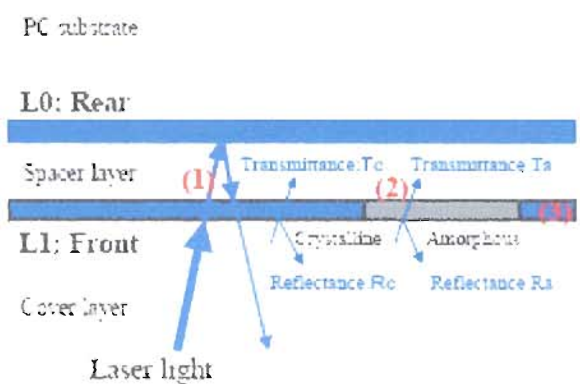

Fig.1.3.3 Transmittance and Reflectance of Dual layered BD

2.0 Future Developments

Currently, there is still research in Blu-ray to have as much applications as DVDs. BD-RE (Blu-ray disc rewritable), BD-RAM (random access memory), BD-R (record), BD-ROM (read only memory) are just a few of the applications that we have with DVD technology and are being developed with the BD standard. Future goals will lie in the speed of recording, since currently it is only at 2x, in driving costs down so that it is available to the public, and in compatibility with CD and DVD.

References:

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Figures:

Fig. 1.1.1. Evolution of optical discs (Ref. 3)

Fig 1.2.1 Durability of plastics (Ref. 3)

Fig. 1.2.2 Emission spectra for GaN laser diodes at room temperature (Ref. 6)

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