HD DVD
promising design

September 6, 2004
@ UNAXIS
Hisashi Yamada (TOSHIBA)
Agenda

• Environment change
  – Market
  – Display
  – HDD//LSI

• Technical design
  – System design
  – Optical design
  – HD DVD family

• Summary
Environmental change

- Market change
- Technology over shoot
- Internet threat
Market projection Worldwide

Source: Techno-research (2004/2)

Toshiba projection

2006, market more than $100 billion

Source: IRMA

DVD Player/Drive market

DVD Disc Market

Million unit

Toshiba projection

10 billion disc

DVD-Audio
DVD-ROM
DVD-Video
DVD-W

CE
PC

230 million

360 billion

2001 2002 2003 2004 2005 2006

2001 2002 2003 2004 2005 2006

2006, market more than $100 billion
Shipments of DVD Video Software in the USA surpassed one billion units in 2003.

Continued growth is expected for another 5-6 years.

Source: Digital Entertainment Group (USA)
Japan Video Software Association (Japan)
Digital TV Market - Japan

Digital TV (TV receiver + STB) Market in Japan

- Following the start of BS (2000) and terrestrial (2003) digital broadcasts, rapid DTV market growth is forecasted
- Sales of 7,630,000 units are expected in 2006, in order to enjoy HD content at home

Source: Toshiba Corp.
Digital TV Market – the USA

- The U.S. DTV market is expected to grow at a faster pace
- The FCC mandate “Integration of DTV tuner in every DTV device of 36 inches and larger by July 2005” will accelerate DTV penetration

Source: CEA
Technology overshoot

1080i/p
720p
480i/p
CIF
QCIF

NTSC is insufficient for large display more than 30inch
HDD recording density

Gbit/inch$^2$

3.5" 1 disk, 2.5" 2 disk

< 60% / Year

60% / Year

30% / Year

100% / Year

Nikkei electronics 12/17/01
LSI design

- Design rule is still emerging
- Integration density will be increased
- Complexity of system can be solved by LSI
- Use advanced signal processing technology
  - PRML
  - Advanced CODEC
  - Improved Modulation ECC
Role of Optical disc

- ROM Video for content distribution will be principal usage
- Recordable media will be used together with HDD
- HDD became primary storage for time shift recording in the home.
- Recordable/ReWritable Optical disc will be used as archival storage for broadcasted content and download content through the Internet
- HD DVD is suitable for either purpose
Internet piracy

• Download Activity experience
  – Total: 24%
  – France: 27%, Germany: 19%, Italy: 20%, Japan 10%, Korea: 58%, UK: 20%, US: 24%

• Peer to peer file copy
  – 2.6 billion copy per month
  – Already, loss to the entertainment industry reached to billions of dollars

Source: MPAA
Environment change

• Display Technology over shoot
  – Too good big display will show current DVD picture quality is poor

• Broadband network threat
  – 28% of general American experienced pirated disc downloaded through Internet
  – Actual damage on business might begin in 2006?

• Need promotion of secure environment in advance. HD DVD can realize quick introduction and long format life for the future
Comprehensive System Design Target

• Provide sufficient quality necessary for HD movie content
• Provide sufficient capacity for 132min movie
• Add new features on current DVD and Internet connectivity
• Provide secure content protection
• Use current DVD production facility and know how already accumulated
• Make low cost production of disc possible
• Assume HDD with ODD in usual home environment
• Optimum design using most advanced CODEC and LSI technology
Technical design

• Reasonable design considering the essential condition for the next generation DVD
• Consistency with DVD
• Optimum from user’s point of view
Pit Comparison of Read-only Disc

viewed through atomic force microscope
4um x 4um

<table>
<thead>
<tr>
<th></th>
<th>CD</th>
<th>DVD</th>
<th>HD DVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>track pitch</td>
<td>1.60 um</td>
<td>0.74 um</td>
<td>Track pitch</td>
</tr>
<tr>
<td>min. pit length</td>
<td>0.83 um</td>
<td>0.40 um</td>
<td>min. pit length</td>
</tr>
<tr>
<td>pit width</td>
<td>0.50 um</td>
<td>0.35 um</td>
<td>pit width</td>
</tr>
<tr>
<td>capacity</td>
<td>650 MB</td>
<td>4.7 GB</td>
<td>capacity</td>
</tr>
</tbody>
</table>
CD>>DVD>>HD DVD

• **CD**: 1.2mm substrate open a way to use precision injection technology and digital signal processing for bit data (modulation and ECC)

• **DVD**: 0.6mm bonding structure open a way to use bonding technology of two discs and more sophisticated digital signal processing and compression technology and digital copy protection

• **HD DVD**: To develop ?
# Technology selection

<table>
<thead>
<tr>
<th>Substrate Thickness</th>
<th>CD</th>
<th>DVD</th>
<th>HD DVD (BrD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NA</td>
<td>0.45</td>
<td>0.6</td>
<td>0.6 x 2 (0.1)</td>
</tr>
<tr>
<td>Capacity (GB)</td>
<td>0.78</td>
<td>4.7/8.5</td>
<td>15/30</td>
</tr>
<tr>
<td>CODEC</td>
<td>none</td>
<td>MPEG2</td>
<td>MPEG4 AVC VC1/MPEG2 (MPEG2&gt;&gt;Same)</td>
</tr>
</tbody>
</table>
### Optical characteristics of HD-DVD/DVD/CD compatible head

<table>
<thead>
<tr>
<th></th>
<th>HD - DVD</th>
<th>DVD</th>
<th>CD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wavelength</strong></td>
<td>405 nm</td>
<td>660 nm</td>
<td>790 nm</td>
</tr>
<tr>
<td><strong>N A</strong></td>
<td>0.65</td>
<td>0.60</td>
<td>0.45</td>
</tr>
<tr>
<td><strong>Focal length</strong></td>
<td>2.60 mm</td>
<td>2.68 mm</td>
<td>2.70 mm</td>
</tr>
<tr>
<td><strong>Disk thickness</strong></td>
<td>0.6 mm</td>
<td>0.6 mm</td>
<td>1.2 mm</td>
</tr>
<tr>
<td><strong>Working Distance</strong></td>
<td>1.2 mm</td>
<td>1.304 mm</td>
<td>1.099 mm</td>
</tr>
<tr>
<td><strong>Magnification</strong></td>
<td>0</td>
<td>-0.0164</td>
<td>-0.0766</td>
</tr>
<tr>
<td><strong>Object distance</strong></td>
<td>INF.</td>
<td>165.24 mm</td>
<td>37.27 mm</td>
</tr>
<tr>
<td><strong>Wavefront aberration</strong></td>
<td>0.0001 λrms</td>
<td>0.0063 λrms</td>
<td>0.0017 λrms</td>
</tr>
<tr>
<td><strong>Chromatic aberration</strong></td>
<td>0.63 μm/nm</td>
<td>0.16 μm/nm</td>
<td>0.11 μm/nm</td>
</tr>
<tr>
<td><strong>Wavefront aberration</strong></td>
<td>0.0001 λrms</td>
<td>0.0071 λrms</td>
<td>0.0258 λrms</td>
</tr>
<tr>
<td><strong>Field angle / Image height</strong></td>
<td>±0.74 deg. / ±34.2 μm</td>
<td>±0.57 deg. / ±25.6 μm</td>
<td>±0.42 deg. / ±19.2 μm</td>
</tr>
<tr>
<td><strong>Disk tilt</strong></td>
<td>±0.15 deg.</td>
<td>±0.34 deg.</td>
<td>±0.56 deg.</td>
</tr>
</tbody>
</table>
## Technical design parameters

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<tbody>
<tr>
<td>Thickness</td>
<td>1.2mm</td>
<td>0.6mm</td>
<td>0.6mm</td>
</tr>
</tbody>
</table>

No! 0.1mm
Systems to be compared

- (A) Current DVD
- (B) 0.1mm cover layer & 0.85 NA system
- (C) 0.6mm cover layer & 0.65 NA system

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<tr>
<td>Wavelength</td>
<td>$\lambda$ ($\mu$m)</td>
<td>0.65</td>
<td>0.405</td>
</tr>
<tr>
<td>Refractive index</td>
<td>$n_0$</td>
<td>1.58</td>
<td>1.62</td>
</tr>
<tr>
<td>Numerical aperture</td>
<td>$NA$</td>
<td>0.6</td>
<td>0.85</td>
</tr>
<tr>
<td>Cover thickness</td>
<td>$d_0$ ($\mu$m)</td>
<td>600</td>
<td>100</td>
</tr>
</tbody>
</table>
Issues to be discussed

- Cover-layer thickness error
- Disk-tilt
- Depth of focus
- Dust on cover
- Tracking error signal (L/G and G-only)
Cover-layer thickness error

Optical scheme

No aberration when cover thickness is $d_0$, and refractive index is $n_0$
Cover-layer thickness error

Models

(1) Well known formula:

\[ W(r) = W_{40}r^4 = \frac{(n_0^2 - 1)}{8n_0^3} d(NA)^4 r^4 \]

(2) By geometrical optics:

\[ W(r) = \left\{ \sqrt{n_0^2 - (NA)^2 r^2} - n_0 + \frac{1}{n_0} - \left( \sqrt{1 - (NA)^2 r^2} / n_0 \right) \right\} d \]
Cover-layer thickness error

Comparison between the two models

- Wave-front aberration for thickness error $d = 10 \, \mu m$
- Geometrical optics
  - Well-known formula
  - Inaccurate for large NA

Thin substrate will not give any advantage over thick substrate
Cover-layer thickness error

Result

RMS-value against cover-layer thickness error

Aberration (rms-value in \( \lambda \)) vs. Cover layer thickness error \( d (\mu m) \)

- \( (d (\mu m), \text{NA}) \)
- \( (100, 0.85) \) (B)
- \( (600, 0.70) \)
- \( (600, 0.69) \)
- \( (600, 0.68) \)
- \( (600, 0.67) \)
- \( (600, 0.66) \)
- \( (600, 0.65) \) (C)
- \( (600, 0.64) \)
- \( (600, 0.63) \)
- \( (600, 0.62) \)
- \( (600, 0.61) \)
- \( (600, 0.60) \) (A)

(A) (C) (B)
Cover-layer thickness error

**Conclusion for cover-layer thickness error**

Margin $d_m$ is defined so that the following expression holds:

“if $|d| < d_m \implies w_{RMS} < 0.0293(\lambda)$”

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<td>100</td>
<td>600</td>
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<tr>
<td>thickness margin $d_m$</td>
<td>30</td>
<td>2.9</td>
<td>12.7</td>
</tr>
</tbody>
</table>

**DVD specification**
Disk-tilt

Optical scheme

No aberration when

\[ \text{cover thickness} = d_0 \]
\[ \text{refractive index} = n_0 \]
Disk-tilt

RMS value of phase error

(1) Well known formula:

\[ W(r, \phi) = W_{31} r^3 \cos \phi = \frac{(n_0^2 - 1)}{2n_0^3} d(NA)^3 r^3 \cos \phi \]

(2) By geometrical optics: This calculation

\[ W(r, \phi) = Optical \ Path \ Difference \ (geometrically \ calculated \ ) \]
Comparison between the two models

- Cover thickness: 600 µm
- Disk tilt: 5 mrad
- Refractive index: 1.62

Aberration (rms-value in µm) vs. Numerical aperture (NA)

- Geometrical optics
- Well-known formula
- Inaccurate for large NA
HD DVD system need a measure to improve tilt margin

>> Tilt servo
Disk-tilt

Conclusion for disk-tilt

Tilt margin $\theta_m$ is defined so that the following expression holds:

“if $|\theta| < \theta_m \implies w_{\text{RMS}} < 0.04(\lambda)$”

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<td>100</td>
<td>600</td>
</tr>
<tr>
<td>Tilt margin $\theta_m$</td>
<td>6.9</td>
<td>6.4</td>
<td>3.2</td>
</tr>
</tbody>
</table>
Depth of focus

Optical scheme

Objectives lens

Cover $n_0$ $d_0$

No aberration when:

- cover thickness = $d_0$
- refractive index = $n_0$

Objectives lens

Cover $n_0$ $d_0 + d_f$
Depth of focus

Diffraction model

\[ W(r) = n_0 d_f \left( 1 - \sqrt{1 - (NA)^2 r^2} \right) \]

This calculation
Depth of focus

Peak intensity

Peak intensity of beam spot

Position of reference plane $d_f$ ($\mu$m)

NA: 0.7, 0.6

(A) (B) (C)
Depth of focus

Beam width

Full beam width at $1/e^2$ maximum ($\mu$m)

Position of reference plane $d_f$ ($\mu$m)

NA: 0.7  0.6

(A)  (B)  (C)
**Depth of focus**

**Conclusion for depth of focus**

Depth of focus $d_f$ is defined as shown in the figure.

<table>
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<td>600</td>
<td>100</td>
</tr>
<tr>
<td>Depth of focus</td>
<td>$d_f$ ((\mu)m)</td>
<td>0.370</td>
<td>0.097</td>
</tr>
</tbody>
</table>
Radial tilt margin improvement

Experimental results of radial tilt servo for ROM disc
Dust noise

Conditions of dust-noise simulation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scanning velocity ( v ) (m/s)</td>
<td>3.49</td>
</tr>
<tr>
<td>Areal density of dust ( D_a )</td>
<td>0.02</td>
</tr>
<tr>
<td>Res. Band Width ( RB ) (kHz)</td>
<td>1.0</td>
</tr>
<tr>
<td>Dust diameter ( d_0 ) (( \mu )m)</td>
<td>1 ~ 20</td>
</tr>
</tbody>
</table>
Dust noise

Result

Dust diameter (µm)

Dust diameter (µm)

Frequency (Hz)

Noise (dB)

HD DVD

BrD

DVD

20

10

5

2

1

20

10

5

2

1
Error Correction Code

• Data Sector : 2064 bytes
  = 4 ID + 2 IED + 6 RSV
  + 2048 Data + 4 EDC

• ECC Block : 32 Data sector
  = 2 RS Product Code

• Inner code : RS(182, 172, 11)

• Outer code : RS(208, 192, 17)

• Row Interleave : Every 12 rows

• Correctable : 4.6mm for 30Gbytes disk
  burst error length : 7.0mm for 15Gbytes disk

• Buffer memory : 160KB
Random error correction capability

Graph showing the relationship between byte error rate before ECC and byte error rate after ECC.
## Modulation method

<table>
<thead>
<tr>
<th></th>
<th>(2,3,1,9) modulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion rate</td>
<td>2 : 3</td>
</tr>
<tr>
<td>Minimum runlength</td>
<td>2T</td>
</tr>
<tr>
<td>Maximum runlength</td>
<td>10T</td>
</tr>
<tr>
<td>DC component suppression control</td>
<td>possible</td>
</tr>
<tr>
<td>Additional DC control bit</td>
<td>0%</td>
</tr>
<tr>
<td>PRML signal processing</td>
<td>suitable</td>
</tr>
</tbody>
</table>
Comparison of spectrum

Channel clock
Proposal : 64.8MHz
Current DVD : 22.16MHz

(2,3,1,9) modulation (Proposal)  8/ 16 modulation (current DVD)
PRML

• Can provide about 20% more capacity than slice method
• SbER, PRSNR were introduced to measure disc characteristics without measuring actual bit error for volume production line
• SbER, PRSNR is rather analog parameter to estimate actual error rate
Binary data recording with Slice method

合成信号がスライスレベルを横切るときに、前の信号の影響は無くなっており、ピットのエッジが正確に検出可能。
PRML (Partial Response Maximally Likelihood)

- Multi-level recording: Assuming interaction between symbols, and estimates the most likelihood signal trajectory. Pit more than limit of OTF can be read.

Single pit response

Total signal response

Read out spot moving direction
PRML (Partial Response Maximally Likelihood)

From the difference of trajectory the actual series of pits can be estimated.
Concepts of ROM/Rewritable/R

- Compatibility between ROM and rewritable disc
- Random writing
- Easy reading of physical address
- Defect management
- -R is same as ROM
Merit of Land & Groove format

- Wide groove pitch
  - Easy to make a disc
  - Large tracking signal
- Land & Groove recording

- Narrow groove pitch
- Groove recording

Recording mark

- 0.58µm
- 0.29µm
Tracking error signal amplitude

Land & Groove Format Brings Large Tracking Error Signal

Signal Amplitude: Normalized by total reflectivity at mirror surface
Advantages of current DVD

- **DVD-RAM**
  - Random access by block writing
  - High track density by land and groove format
  - Defect management on physical layer

- **DVD-RW**
  - Almost same readout data signal as DVD-ROM by wobble and Land Pre-Pit (LPP)
  - Continuous groove
Current DVD-RAM

- **Single spiral track**
  - Tracking polarity should be switching every one revolution. Makes drive design difficult

- **CAPA**
  - Header is not set at the center of beam spot-difficult to make Pick up
Current DVD-RW

• Loss less linking makes error bits.
  Because some connection data are damaged by loss less linking, because there is not buffer area.

  ![Diagram of SYNC and 16 bytes]

• Land Pre-Pit (LPP)
  – LPP reading is difficult because it is not set at the center of beam spot.
Compatibility between ROM and ReWritable disc

- Wobble address scheme realizes same ROM data format as ReWritable.
- New wobble address allows to read both land track and groove track address even Land & Groove format is used.
- Simple mastering by 1beam mastering machine is achieved
Gray code and L & G format

L   N   N+1   N
G   N   N+1
L   N+1  N+2
G   N+1  N+2
L   N+2  N+3
G   N+2  N+3
Wobble address

- Groove width modulation gives address signals for land track.
- Gray codes are adopted for address data.

Only 1 bit of track address data is different from adjacent track address data.
Random writing

- Recording block consists of one ECC block, and the recording block has buffer area for linking. Therefore, lossless linking is available without error.
- Start point of the recording data is shifted randomly within 168 channel bits for increasing over write cycle.
Easy physical address reading

- Wobble address signal uses phase modulation.
  And 84% of wobbles is fixed phase.
  Therefore, wobble PLL can be locked easily.
Defect Management

- Defect management tables are located at Lead-in area and Lead-out area.
- Defect management will be made by drive
Land and Groove format

• Land and Groove track structure
• Double spiral track
  – Continuous groove track
  – Continuous land track
  – Transition from Land to Groove will not require additional memory
  – No track switching during a recording
Zoned CLV format

- **Zoned CLV in rewritable data area**
  - The number of zone in the Data area is 19.
- **CLV in embossed data area**
- **Low density embossed pits in Lead-in area**
  - Common for ROM and rewritable disc

<table>
<thead>
<tr>
<th>Zone number</th>
<th>Number of segment per track</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>31</td>
</tr>
</tbody>
</table>
## Conclusion

System allowances are theoretically studied and are summarized below:

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<td>100</td>
<td>600</td>
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<tr>
<td><strong>Thickness margin</strong> $d_m$ ($\mu$m)</td>
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<td><strong>Depth of focus</strong> $d_f$ ($\mu$m)</td>
<td>0.370</td>
<td>0.097</td>
<td>0.187</td>
</tr>
<tr>
<td><strong>Dust noise</strong> $N$ (dB)</td>
<td>$N_0$</td>
<td>$N_0+10 \sim 20$</td>
<td>$\approx N_0$</td>
</tr>
</tbody>
</table>
DVD Forum

• Steering Committee on June 9-10
  – MPEG2, MPEG4 AVC(H.264) and VC-9 were approved as mandatory CODEC for Video
  – HD DVD-ROM Ver. 1.0 was approved

• WG-11/TG11-1
  – HD DVD-R round robin test has been made and will be finished in August, 7 companies submitted good sample discs
  – Draft specification for Ver.0.9 was distributed
  – HD DVD-R specification Ver. 0.9,
    • RRT(16 companies participated) is finished
    • To be approved at Sept. Steering Committee
WG-11 members (79 companies as of March 24, 2004)

Almedio Inc.
ALPINE Corporation
AMC CO., LTD
ASAHI KASEI MICROSYSTEMS CO., LTD.
AudioDev AB
Cheertek Inc.
Ciba Specialty Chemicals Holding Inc.
Cinram Manufacturing Inc.
CMC Magnetics Corporation
Columbia Music Entertainment, Inc.
CREST NATIONAL
DCA Inc.
Deluxe Media Services, Inc.
DiskWare CO., LTD.
Digital Theater Systems, Inc.
Dolby Laboratories Inc.
Eclipse Data Technologies
FUJI PHOTOFILM CO., LTD.
Funai Electric Co., Ltd.
Hitachi, Ltd.
IBM Corporation
Industrial Technology Research Institute (ITRI)
Infodisc Technology Co., LTD.
Interaxia AG
KENWOOD CORPORATION
Leader Electronics Corp.
LG Electronics Inc.
LITEON IT Corp.
LSI Logic Corporation
MediaTek Inc.
MEMORY-TECH CORPORATION
Meridian Audio Limited
Microsoft Corporation
MIPS Technologies
Mitsubishi Chemical Corporation
Mitsubishi Electric Corporation
MITSUI CHEMICALS, INC.
Moser Baer India Limited
NEC Corporation (Chair company)
Optodisc Technology Corporation
PIONEER CORPORATION
Pixonics, Inc.
Prodisc Technology Inc.
PULSTEC INDUSTRIAL CO., LTD.
RICOH COMPANY, LTD.
RITEK CORPORATION
ROXIO, Inc.
SAMSUNG ELECTRONICS CO., LTD.
SANYO Electric Co., Ltd (V-chair)
Scientific Atlanta Inc.
Seiko Epson Corporation
SHARP CORPORATION
Shibasoku Co., Ltd.
Shinano Kenshi Co., Ltd.
Sigma Designs, Inc.
SINGULUS TECHNOLOGIES AG
SKC Limited.
Sonic Solutions
STMicroelectronics K.K.
Sunext Technology Co., Ltd.
TAIYO YUDEN CO., LTD
TDK Corporation
TEAC CORPORATION
Texas Instruments Japan Limited
Thomson
Time Warner (V-chair, Ex-chair)
TOPTICA Photonics AG
Toshiba Corporation (V-chair, Ex-chair)
Twentieth Century Fox Film Corporation
Unaxis Balzers Ltd.
Victor Company of Japan, Limited
Walt Disney Pictures & Television
YAMAHA CORPORATION
Yokogawa Electric Corporation
Zoran Corporation
Video application

- New advanced and efficient CODECs
  - MPEG4 AVC/ VC-1/ MPEG2
- New interactive features
  - Combination with web content
  - Improved graphic
- Internet capability
  - Access content provider web site
  - New application
Multi-CODEC

Content provider

Any of CODEC stream 1 to 3

ROM-Video Disc

Decoder 1
Decoder 2
Decoder 3

Player

Consumer Recorder/Player

Download content

Any of Encoders 1 to 3

Recordable disc

Decoder 1
Decoder 2
Decoder 3
Bit rate reduction for High Definition content
Example

8.5GB red laser DVD
- 90min HD content @ 8Mbps = 5.45GB
- 90min SD content @1Mbps = 0.7GB
- 90min 3 language × 2 sets = 1.4GB

= 7.55GB

15GB blue laser DVD
- 132min HD content @12Mbps = 12GB
- 132min SD content @1Mbps = 1GB
- 132min 3 language tracks × 2 sets = 2GB

= 15GB

30GB blue laser DVD
- 132min HD content @12Mbps = 12GB
- 132min SD content @1Mbps = 1GB
- 132min LPCM 48ksample 20bit 5.1ch = 4.56GB ➔ 3GB*
- ×3 language = 9GB * If lossless coding is applied

= 22GB*

* If lossless coding is applied
Copy protection

- AACS (Advanced Access Content System) was announced to the public at CPTWG on July 14th.
  - Founders(8 company): Disney, IBM, Intel, Matsushita, Microsoft, Time Warner, Toshiba, Sony
    - AES 128 bit encryption
    - Tree based Media Key Block to make precise key revocation
    - Enhanced Drive Authentication – Device key for drive
    - Network connectivity
    - Disc manufacturer ID bound to key
    - Unlock content by internet
- New business opportunity for Content holders
- HD DVD will adopt this technology
- BD might adopt this technology
Full Compatible Optical head

- The newly developed optical head can drive CD, DVD and HD DVD discs with **single objective lens**.
- More economical than dual-lens head or dual optical heads

<table>
<thead>
<tr>
<th>3 Laser diodes System</th>
<th>CD</th>
<th>DVD</th>
<th>HD DVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave length</td>
<td>780nm</td>
<td>650nm</td>
<td>405nm</td>
</tr>
<tr>
<td>Lens NA</td>
<td>0.45</td>
<td>0.6</td>
<td>0.65</td>
</tr>
<tr>
<td>Substrate thickness</td>
<td>1.2mm</td>
<td>0.6mm</td>
<td>0.6mm</td>
</tr>
<tr>
<td>Working distance</td>
<td>1.5mm</td>
<td>1.7mm</td>
<td>1.7mm</td>
</tr>
</tbody>
</table>

Read out signal eye-pattern
# Second generation DVD specification

<table>
<thead>
<tr>
<th>Capacity (Single/Double)</th>
<th>HD DVD</th>
<th>Blu-ray</th>
<th>DVD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROM</td>
<td>15/30 GB</td>
<td>25/50?GB</td>
<td>4.7/8.5GB</td>
</tr>
<tr>
<td>-R</td>
<td>15GB</td>
<td>? GB</td>
<td>4.7GB</td>
</tr>
<tr>
<td>RAM/RW</td>
<td>20/32~ GB</td>
<td>25/50 GB</td>
<td>4.7GB</td>
</tr>
</tbody>
</table>

| Laser wavelength        | 405nm | 405nm | 650nm |

| Disc structure          | 0.6mm ×2 | 0.1mm cover +1.1mm sub. | 0.6mm ×2 |
| Pick Up lens NA         | 0.65 | 0.85 | 0.6 |

| Disc thickness error    | Single layer 55+-15μm | Dual layer 20+-5μm | 100 ± 3μm |
Disc spec summary

• BrD has slightly more capacity than HD DVD
• Capacity difference is disappearing because of efficient CODEC
• Manufacturing cost is the key issue for ROM
• HD DVD-ROM manufacturing is already completed
• Refer the examples
Second generation DVD specification Summary

- New copy protection will be applied
- The advanced efficient CODECs will be applied to Standard Definition content and High Definition content
- New CODECs will extend recording time 2-3 times
- The new Video specification will be applied to both red laser DVD and Blue laser DVD
- Some advanced features like web connectivity will be introduced
Basic Concept of HD DVD Video

HD Video Format with new Copy Protection

SD Video Format with CSS

Current DVD Discs

Short Movie

3X ROM

Long Movie

HD DVD Discs
Bit rate calculation

Y2002: MPEG2 22M bps was adopted for DVHS and Japanese broadcasting by Constant bit rate

⇒ 6-12Mbps is enough to provide equivalent picture quality after 2 years

⇒ More bit rate reduction (30-50%) can be expected by Variable Bit Rate

⇒ 15GB (HD DVD single layer) can provide enough playing time

8Mbps 132min movie: 8GB

LPCM 5.1ch, 48k s/s, 16bit: 4.6Mbps ⇒ 3Mbps (with lossless)
Example

8.5GB red laser DVD—SD long time 12hr

660min (10Hr) SD content @1Mbps = 5.45GB
660min Audio: AC-3 @384kbps = 2.09GB \[\{7.54\} \text{GB}\]

15GB blue laser DVD—SD long time 24hr

24hr SD content @ 1Mbps = 10.9GB
24hr Audio: 384kbps (AC-3) = 4.18GB \[\{15.08\} \text{GB}\]

30GB blue laser DVD—SD long time 47hr

47hr SD content @1Mbps = 21.36GB
47hr Audio @384kbps = 8.2GB \[\{29.56\} \text{GB}\]
Disc manufacturing

(A) 2 layer Disc manufacturing
same as current DVD

(B) 2 layer disc manufacturing
of 0.1mm substrate disc

0.6mm injection mold disc

1.1mm injection mold disc

Very flat film
Bonding

<3μm accuracy
within 1 rotation

Reflective layer deposition

Discard
Residual dust

Injection mold stumper

Special glue + film

Blue laser

75μm film

JCII2003

Blue laser

Reflective layer deposition

10μm : tolerance

Bonding

Discard
Residual dust

Injection mold stumper

Special glue + film

75μm film

<3μm accuracy
within 1 rotation

Reflective layer deposition

Discard
Residual dust

Injection mold stumper

Special glue + film

Blue laser

75μm film
HD DVD disc manufacturing

• Memory Tech new manufacturing line can make 1 disc/3.5 sec.
• It can change production line from DVD to HD DVD or vice versa in 5 minutes
• 90-95% yield is already achieved
• Cost for the new manufacturing line is almost same as existing line
• Naturally, HD DVD manufacturing line will be increased to 20-50% of total DVD manufacturing line within 3 years
• The existing manufacturing line can be used at a little longer cycle time
New DVD/HD DVD compatible line

DVD/HD DVD compatible line 2~3sec/disc

DVD manufacturing line can be used for HD DVD ~7sec/disc
Basic concept of HD DVD

DVD Master

HD DVD Master

DVD/HD DVD compatible Manufacturing line

DVD Disc

HD DVD Disc

DVD/HD DVD compatible Player
HD DVD yield merits

• DVD/HD DVD compatible player can be realized at reasonable cost – steady and smooth introduction of player can be expected

• DVD/HD DVD compatible disc manufacturing line will be introduced without costly new investment

• Compatible player deployment can rely on current DVD titles at the introduction

• Source tape in the studio is already HD quality by HD telecine.
Summary

• Comprehensive design to establish:
  – Low cost disc manufacturing
  – Compatible disc manufacturing with DVD/HD DVD
  – Sufficient recording time for content providers
  – Superior picture quality for general consumers
  – Reasonable optical system for compatible player
  – Security by AACS
  – Smooth transition from DVD to HD DVD

• Enjoy HD Video quality pictures!