



# High Resolution Dye-Polymer Mastering for HD-DVD and Blu-ray Disc Formats

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# High Density Mastering for Next Generation

## Prerecorded HD-DVD and Blu-ray Disc Mastering Challenges

- **Feature Size & Repeatability**
- **Mechanical & Servo Stability**
  - ⇒ Track Pitch:  $3\sigma \leq 10 \text{ nm}$
  - ⇒ Focus Servo System

Format (Single Layer)	DVD	HD-DVD	Blu-ray Disc
Capacity	4.7 GB	15 GB	25 GB
Track Pitch	740 nm	400 nm	320 nm
Minimum Pit Length	400 nm	204 nm	149 nm
Pit Width (1/2 of Spot Size)	~ 270 nm	~ 160 nm	~ 120 nm
Relative Physical Density	1X	3.6X	6.2X

# High Resolution Dye-Polymer Mastering for HD-DVD and Blu-ray Disc Formats

## High Resolution Dye-Polymer Mastering - Key Features

- ⇒ “Super Resolution” – Feature Sizes  $\frac{1}{2}$  of Record Spot Achievable
- ⇒ “Direct Effect” Thermal Mastering – Enables Direct-Read-After-Write (DRAW)
- ⇒ Switchable Glass Mastering between HD-DVD and BD Formats (351 nm / 0.90 NA)

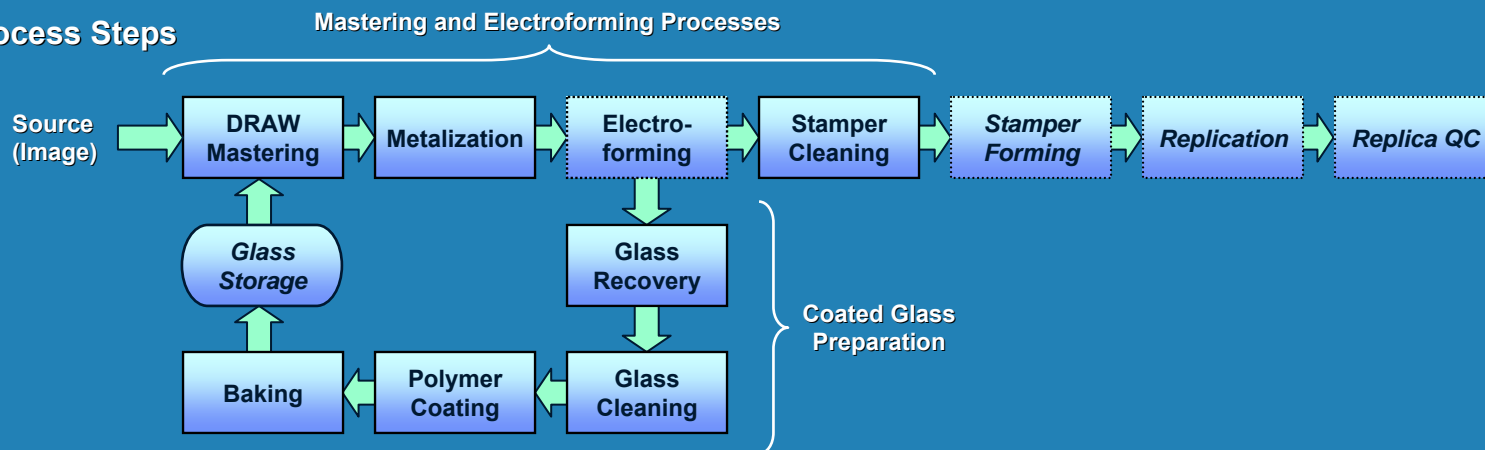
## Outline

- Process Steps
- Critical Signal Parameters for HD-DVD and BD Affected by Mastering
- Optimization Methodology for HD-DVD and BD Signal Parameters
- Recent Results
- Summary & Conclusions

# High Resolution Dye-Polymer Mastering

## Process Steps & Critical Replica Signals

### Process Steps

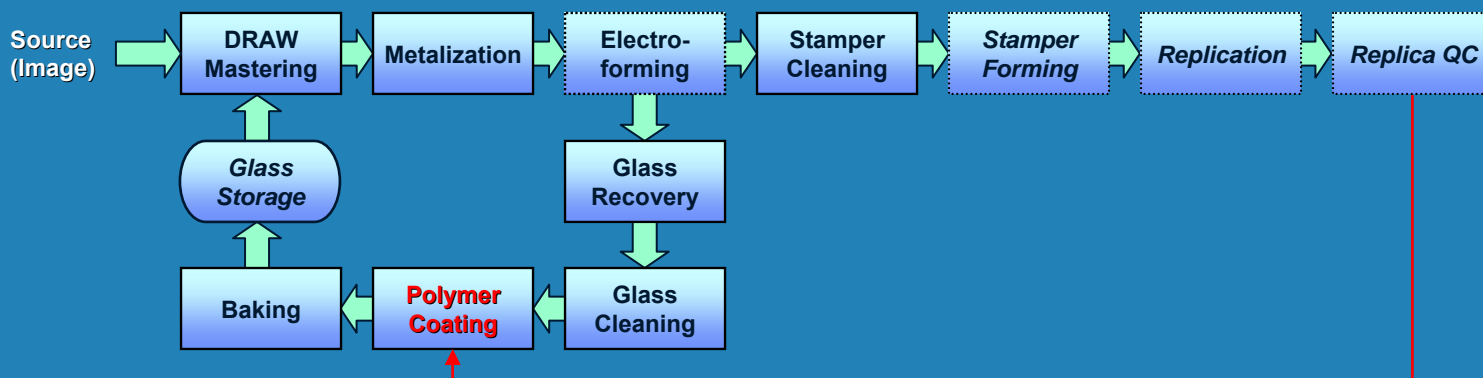


### Critical Replica Signals Affected by the Mastering Process

Parameter	HD-DVD	Blu-ray	DVD
HF Signal Amplitude	I11/I11H	I8/I8H	I14/I14H
Asymmetry	I2 & I3	I2	I3
HF Signal "Quality"	PRSNR	Jitter	Jitter
Digital Error Rate	PI (& SbER)	SER	PI

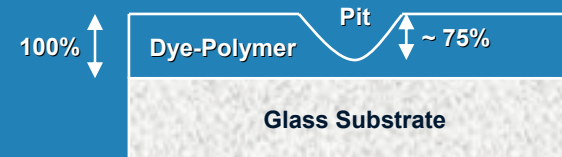
# High Resolution Dye-Polymer Mastering

## Mastering Process Impact on HF Signal Amplitude



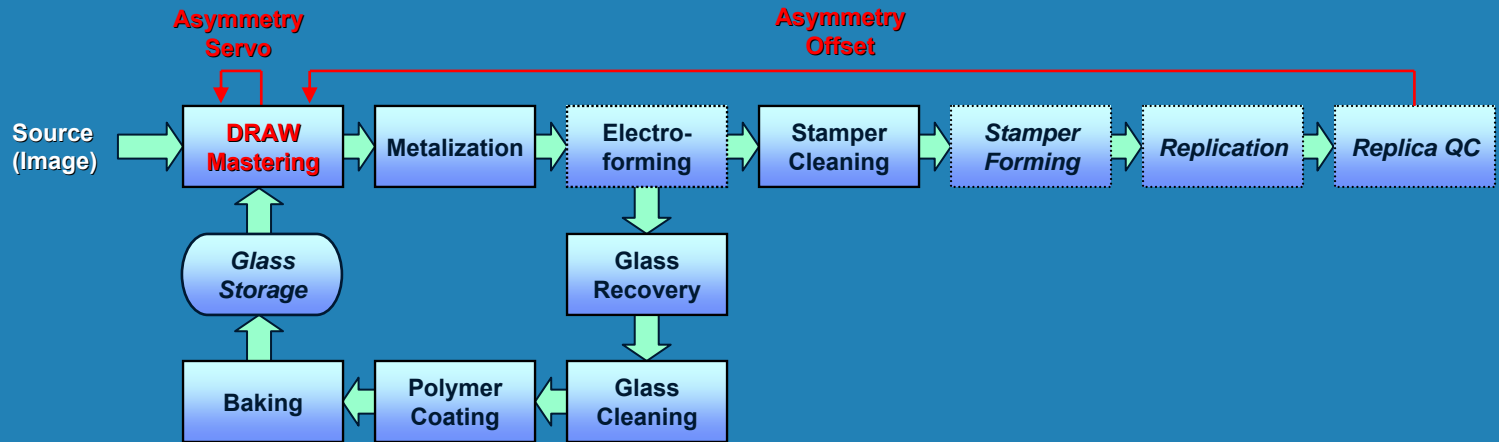
Parameter	HD-DVD	Blu-ray
<b>HF Signal Amplitude</b>	<b>I11/I11H</b>	<b>I8/I8H</b>

- ⇒ Predominantly Set by Dye-Polymer Thickness
- ⇒ Selected to Yield Max Amplitude ( $\lambda/4$  effective pit depth)
- ⇒ Thickness Tolerance Forging



# High Resolution Dye-Polymer Mastering

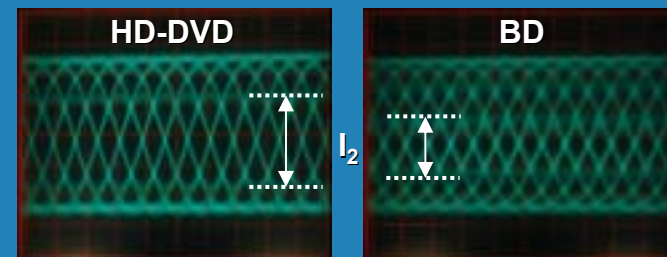
## Mastering Process Impact on Asymmetry



Parameter	HD-DVD	Blu-ray
<b>Asymmetry</b>	<b>I2 &amp; I3</b>	<b>I2</b>

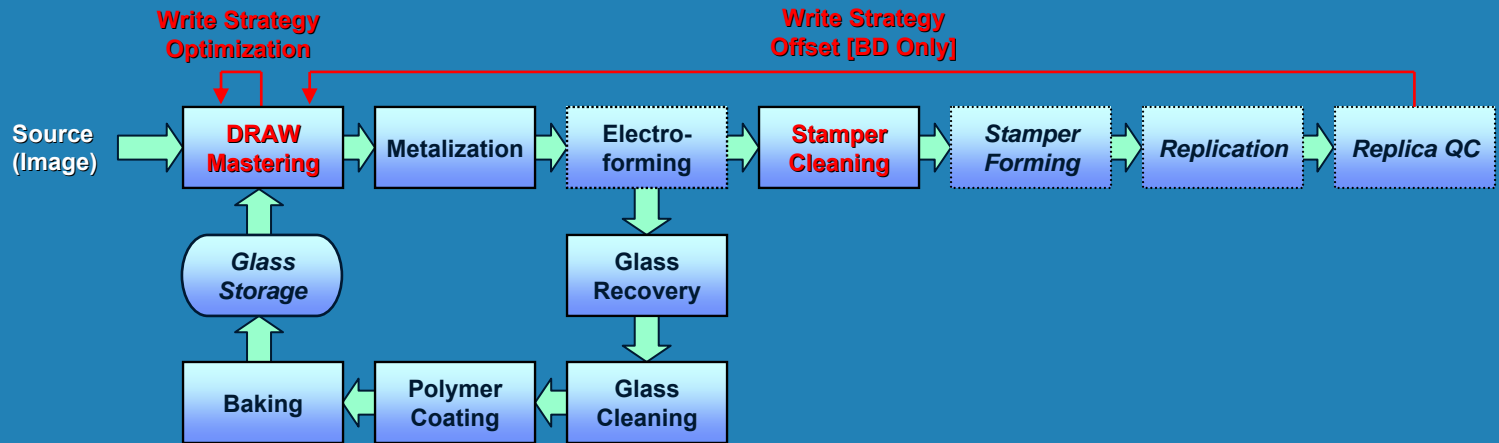
- ⇒ DRAW Servo Control of Asymmetry (within  $\pm 0.5\%$ )
- ⇒ Write Strategy Required by DRAW Couples I2 & I3 Asy.
- ⇒ Replica Data Sets Offset to DRAW Asymmetry

DRAW Signals (during Mastering)



# High Resolution Dye-Polymer Mastering

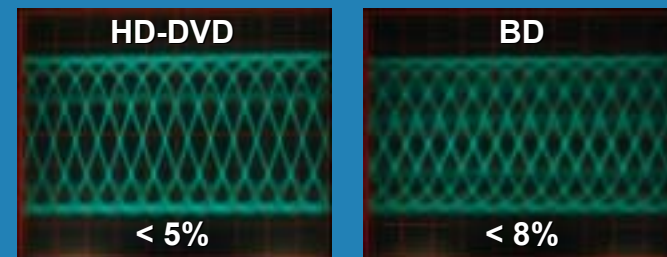
## Mastering Process Impact on HF Signal “Quality”



Parameter	HD-DVD	Blu-ray
<b>HF Signal “Quality”</b>	<b>PRSNR</b>	<b>Jitter</b>

- **HD-DVD: High PRSNR**
  - ⇒ Write Strategy Optimized per DRAW
  - ⇒ Asymmetries I2 and I3 Must be Near 0% on Replica
  - ⇒ Stamper Must be Clean
- **BD: Low Jitter**
  - ⇒ Write Strategy Optimized per DRAW as Reference
  - ⇒ Offsets to Write Strategy as Dictated by Replica
  - ⇒ Higher Order Write Strategy Compensation

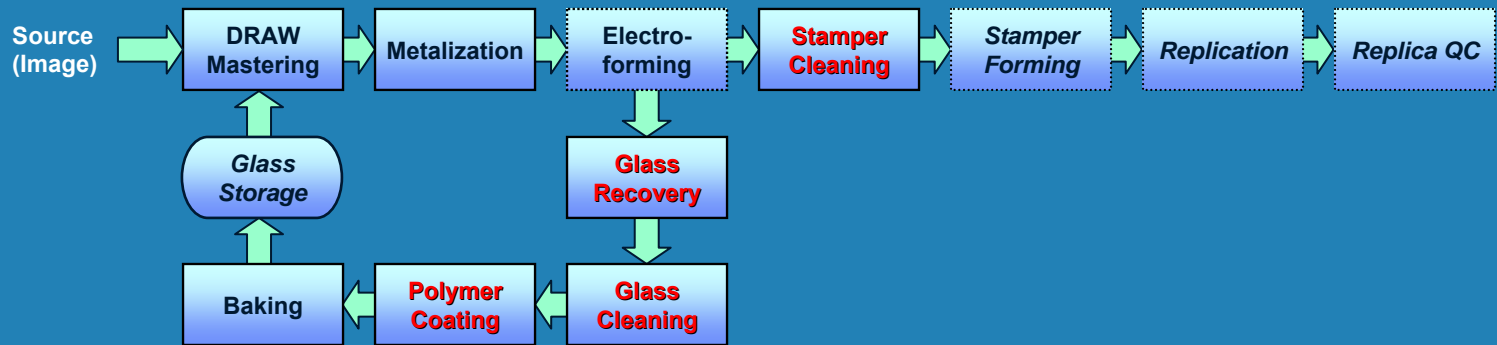
Optimized DRAW Signals



Jitter (Unequalized)

# High Resolution Dye-Polymer Mastering

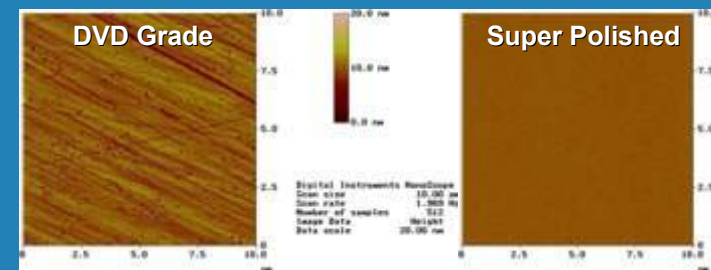
## Mastering Process Impact on (Hard) Digital Error Rate



Parameter	HD-DVD	Blu-ray
Digital Error Rate	PI	SER

- HD-DVD: Low PI
  - ⇒ Process Cleanliness
  - ⇒ Glass Recovery ~ 5 Cycles (DVD Grade Substrate)
  
- BD: Low SER
  - ⇒ Process Cleanliness
  - ⇒ Improved Glass Surface Quality Required
  - ⇒ Glass Recovery - TBD

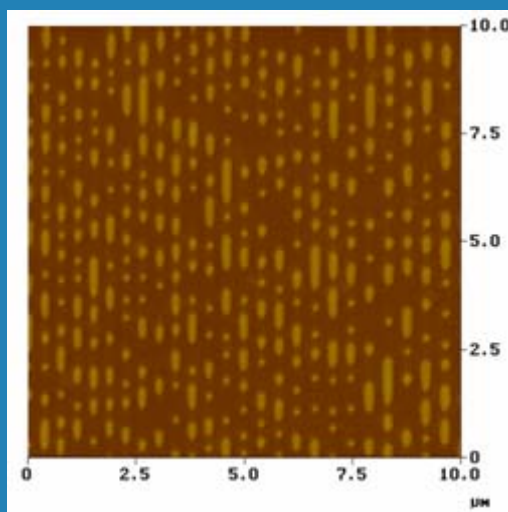
AFM Surface Scans of Glass Substrates



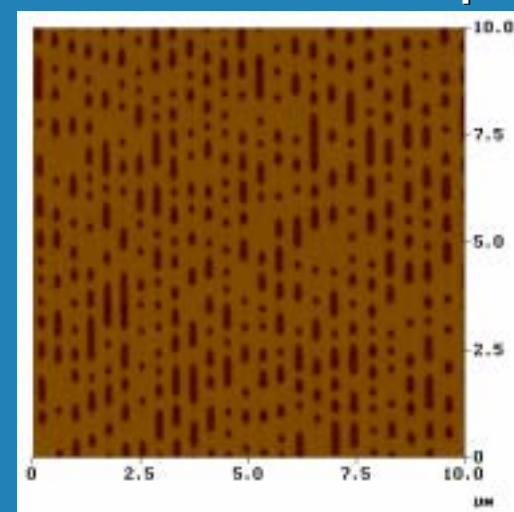
# HD-DVD (15GB) ROM Performance

ODC Nimbus HD LBR 351nm / 0.90 NA

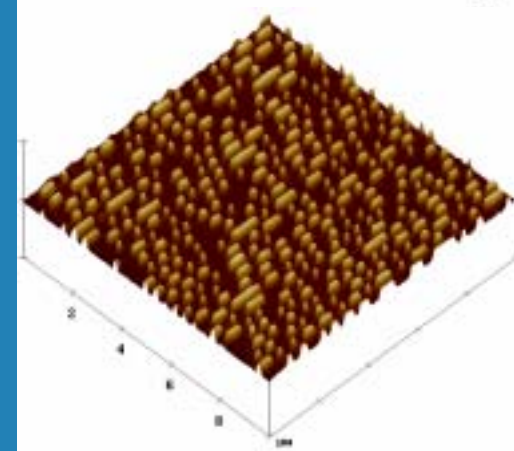
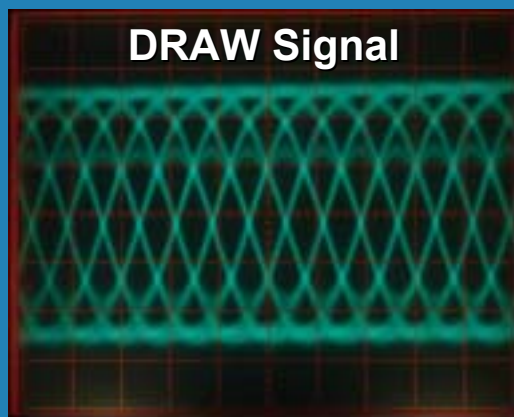
15 GB HD-DVD Master



15 GB HD-DVD Stamper



DRAW Signal



# Critical Replica Signals Achieved: HD-DVD

ODC Nimbus HD LBR 351nm / 0.90 NA

- 1R Mastering Speed
- DVD-Grade Substrates (180mm x 1.6mm)
- MDS BM1.5/Sumitomo SD40E/Seikoh Giken UR/Unaxis Swivel 2003
- Pulstec HD-DVD Inspector

Parameter	Achieved	Typical Range	Requirement
I11/I11H (SL)	0.93	0.88 – 0.92	≥ 0.40
Asymmetry (I2* & I3)	0%	-1% to +4%	-10% to +10%
PRSNR **	43	25 - 40	≥ 15
SbER	1E-10	< 1E-6	≤ 0.5E-5
PI	1	< 100	≤ 280
Jitter (System LI) **	3%	3% – 5%	≤ 8%

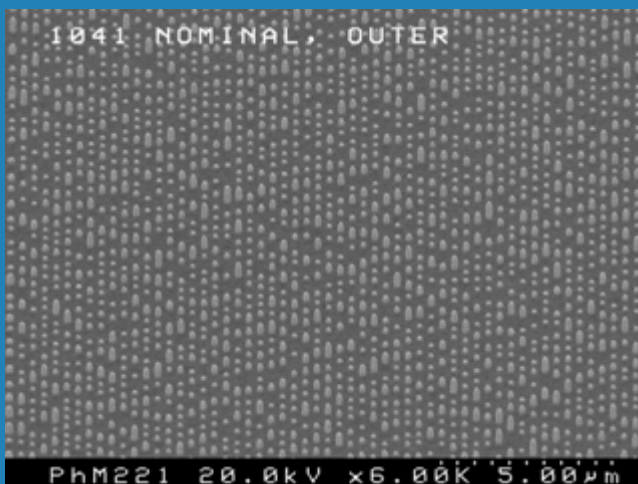
\* DRAW Servo Controlled

\*\* DRAW Optimized

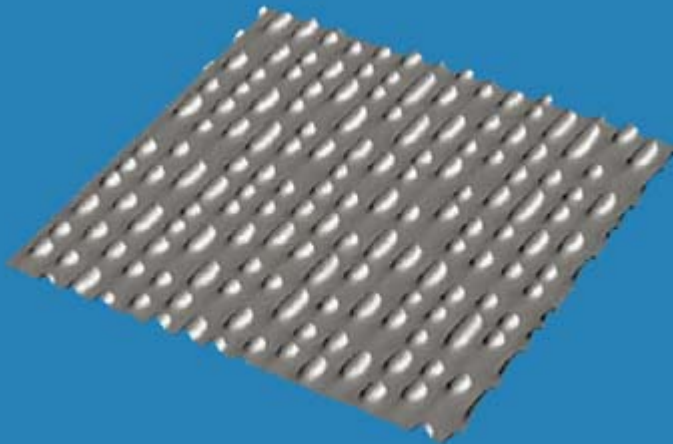
# Blu-ray (25 GB) ROM Performance

ODC Nimbus HD LBR 351nm / 0.90 NA

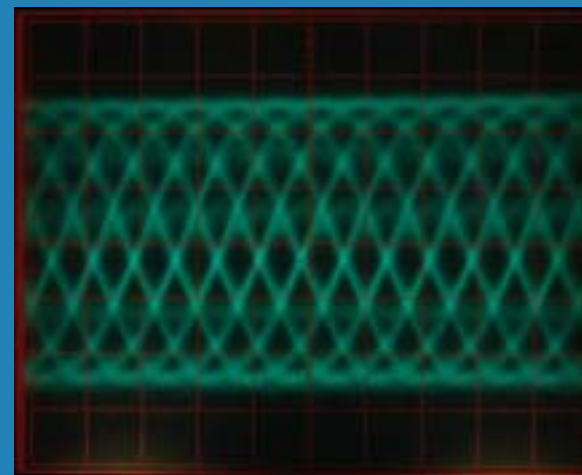
SEM Picture of an HD LBR Blu-ray Stamper



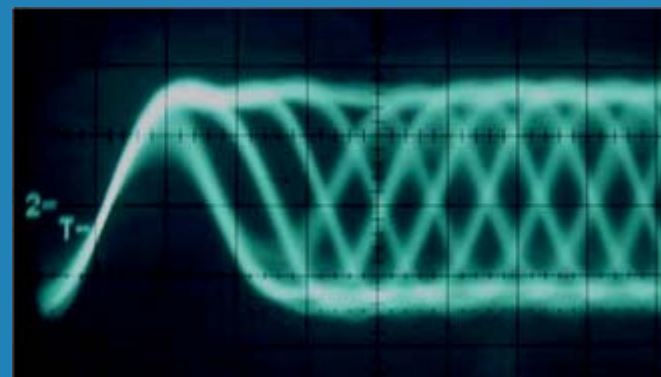
AEM Picture of an HD LBR Blu-ray Stamper



DRAW Signal (Unequalized)



Replica Playback Signal (Limit Equalized)



Pulstec Blu-ray Disc Tester

# Critical Replica Signals Achieved: Blu-ray Disc

ODC Nimbus HD LBR 351nm / 0.90 NA

- 1R Mastering Speed
- Super Polished Substrates (180mm x 1.6mm)
- Singulus Blu-Line (Film Cover Layer)
- Pulstec BD Inspector

Parameter	Achieved	Typical Range	Requirement
I8/I8H	0.93	0.85 – 0.92	≥ 0.40
I2 EQ. Resolution	0.20	0.15 – 0.20	≥ 0.090
Asymmetry (I2) *	5%	4% to 8%	-10% to +15%
Push Pull	0.25	0.15 – 0.25	≥ 0.10 ; ≤ 0.35
Jitter **	4.8%	5.0% – 5.9%	≤ 6.5%
Random SER (LDC)	3E-5	< 1.5E-4	≤ 2E-4

\* DRAW Servo Controlled

\*\* Replica Optimized / DRAW Referenced

# High Resolution Dye-Polymer Mastering for HD-DVD and Blu-ray Disc Formats

## Summary & Conclusions

- **HD-DVD**
  - Tight Asymmetry Control for both I2 and I3 is Pivotal for Good PRSNR
  - Dye-Polymer DRAW Mastering Actively Servos on I2 Asymmetry
  - I2 and I3 Asymmetries are Coupled via Optimum Write Strategy for DRAW
  
- **Blu-ray Disc**
  - Jitter and Error Rates are Key Measures
  - Write Strategy is Referenced to DRAW Signal (during Mastering)
  - Offsets to Write Strategy Obtained from Replica QC are Required
  - Superior Glass Surface Quality Necessary for Low Error Rates