

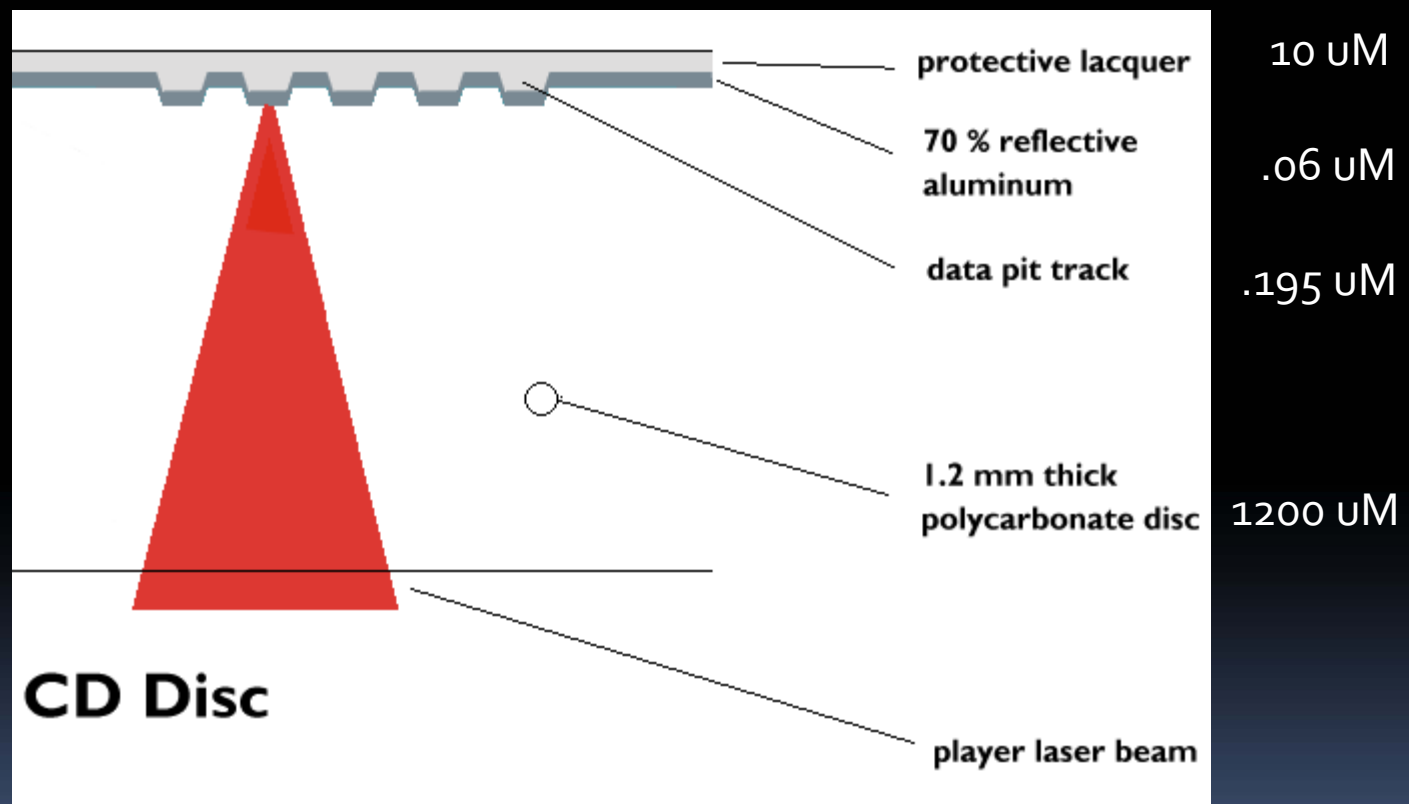


A virtual plant tour

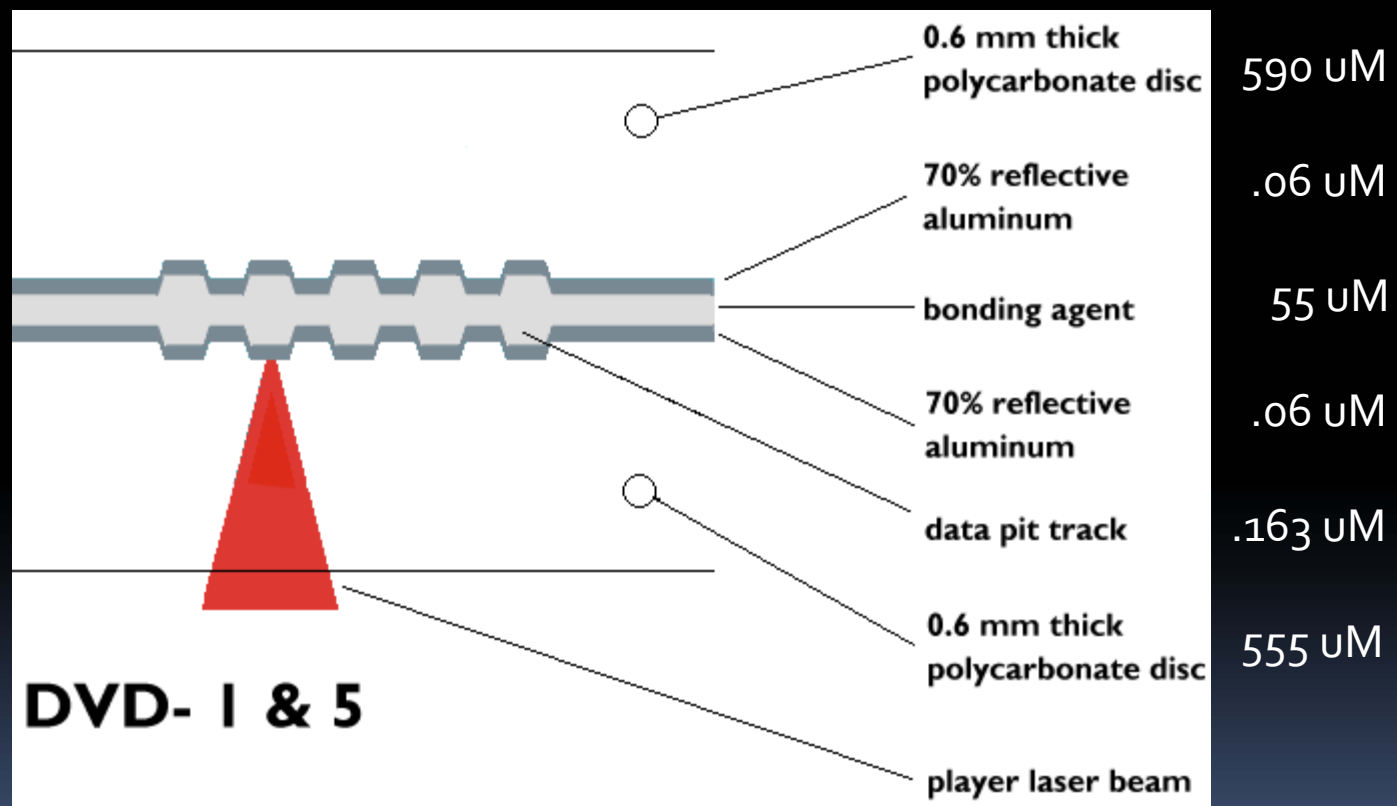
# OPTICAL DISC REPLICATION

Howard Hoyt - 2012

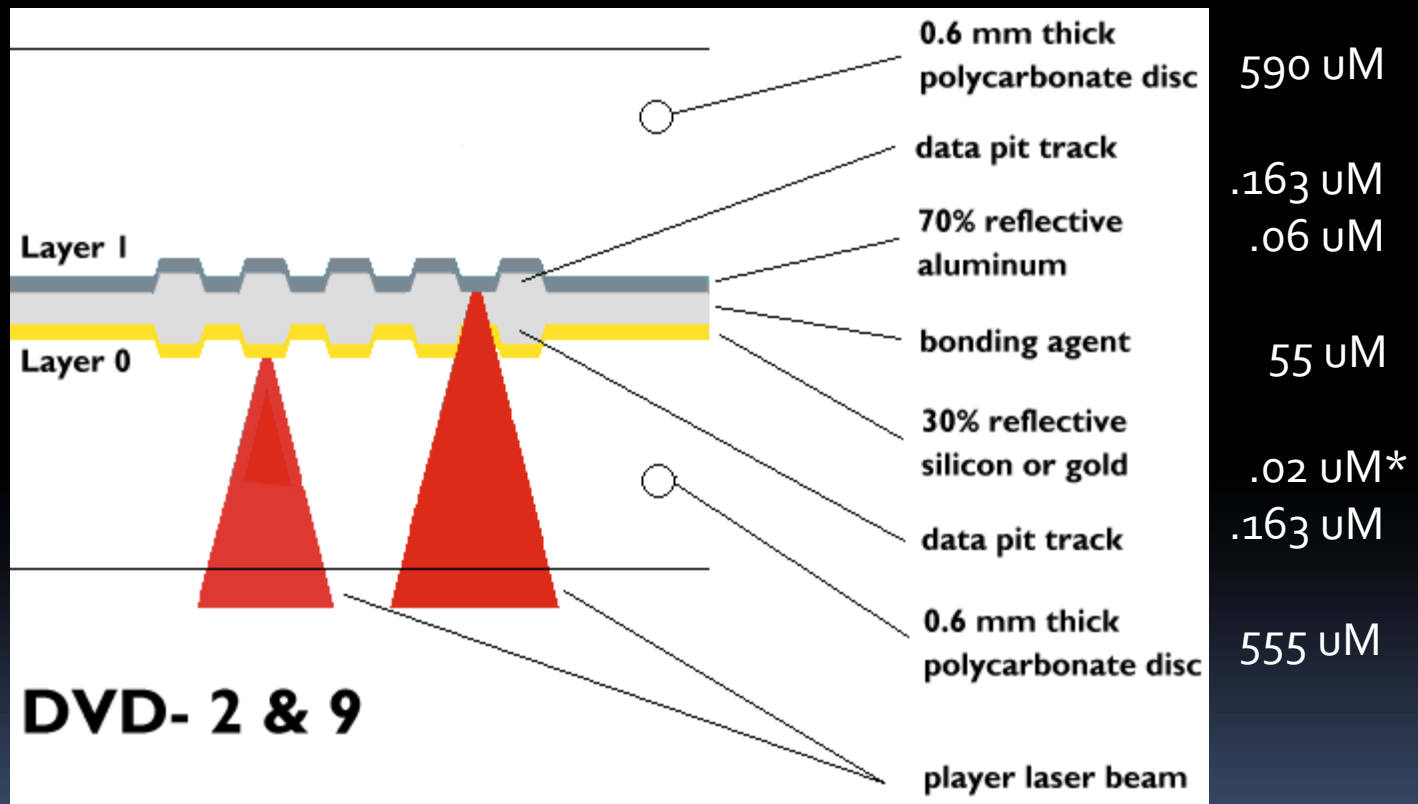
# Optical Disc Types



# Optical Disc Types

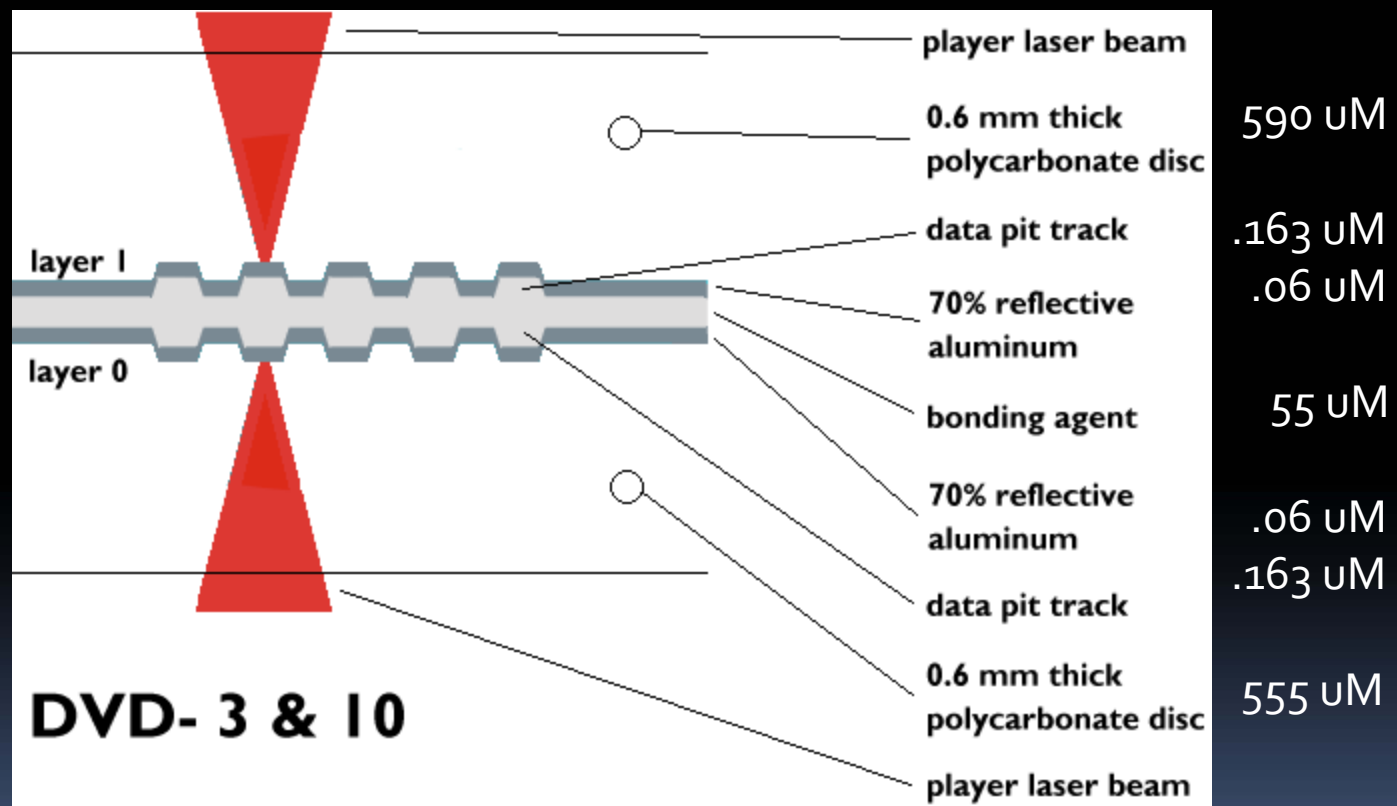


# Optical Disc Types

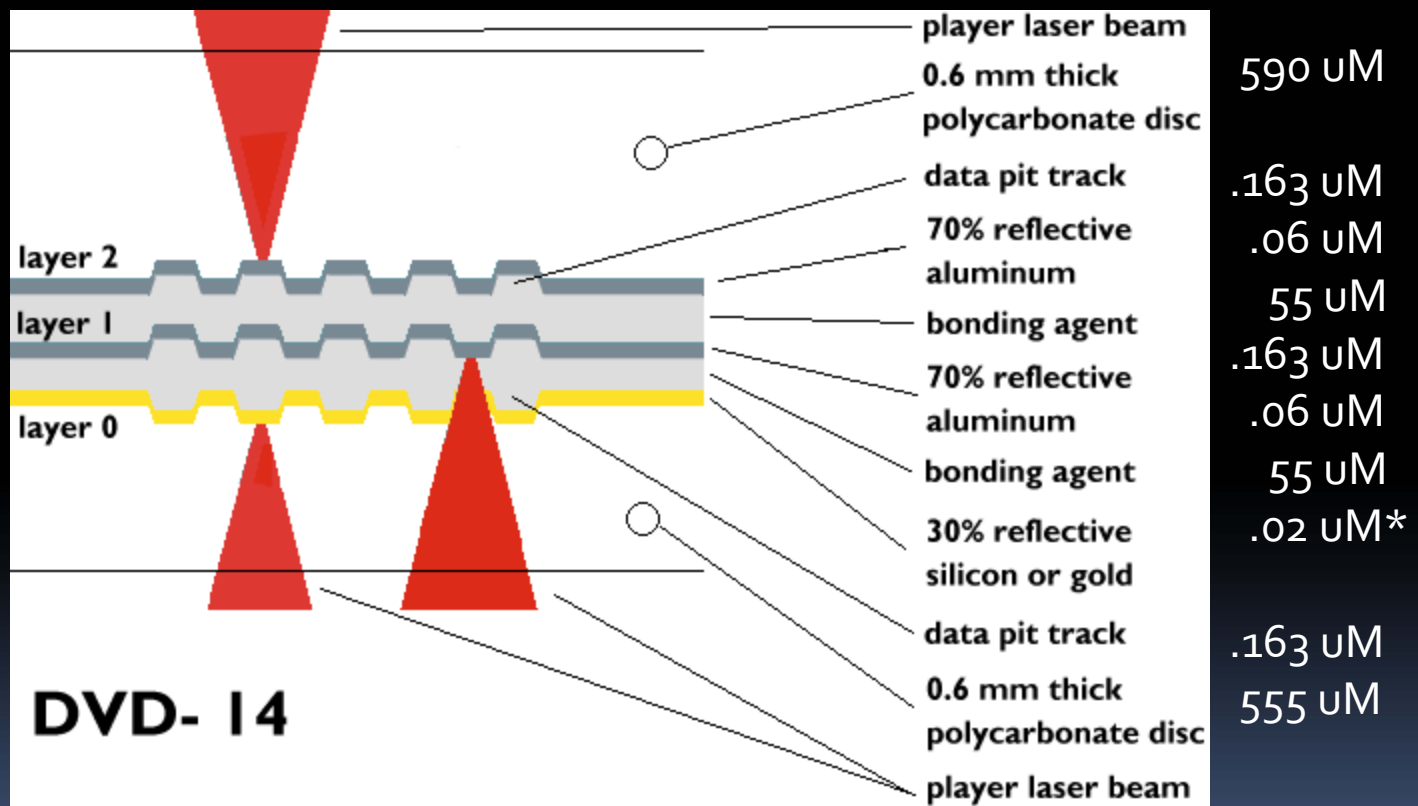


\* - varies by metal

# Optical Disc Types

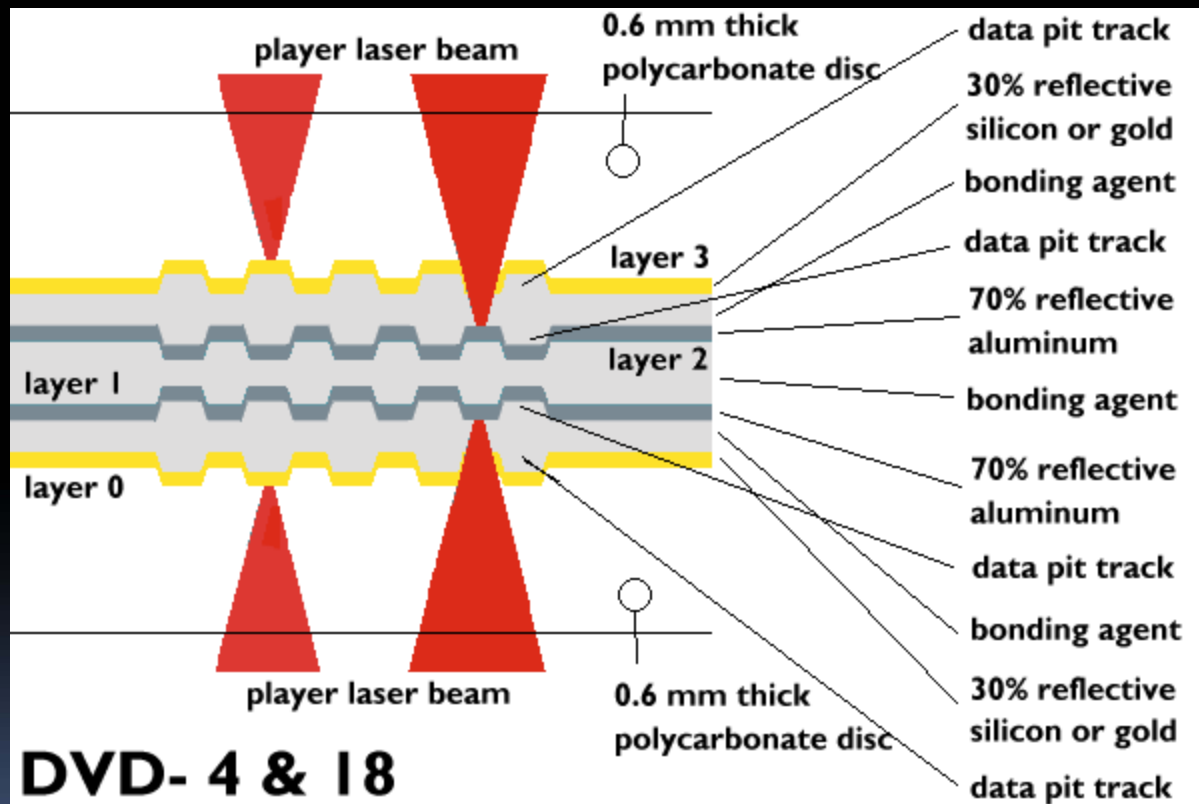


# Optical Disc Types



\* - varies by metal

# Optical Disc Types



**DVD- 4 & 18**

590  $\mu\text{M}$   
 .163  $\mu\text{M}$

.02  $\mu\text{M}^*$   
 55  $\mu\text{M}$   
 .163  $\mu\text{M}$   
 .06  $\mu\text{M}$

55  $\mu\text{M}$   
 .06  $\mu\text{M}$

.163  $\mu\text{M}$   
 55  $\mu\text{M}$   
 .02  $\mu\text{M}^*$

.163  $\mu\text{M}$   
 555  $\mu\text{M}$

\* - varies by metal

# Optical Disc Types

## Optical Disc Storage Characteristics

Format Name	Disc Size	Number of sides	Number of Layers per side	Data Storage Capacity	Video Playing Time, at average DVD quality video, with 5.1 Channel Dolby Audio
CD-ROM	80 mm	1	1	0.20 Gb = 200 Mb	N/A
CD-ROM	120 mm	1	1	0.65 Gb = 650 Mb	N/A
DVD-1	80 mm	1	1	1.36 Gb = 1360 Mb	about half an hour
DVD-2	80 mm	1	2	2.47 Gb = 2470 Mb	about 1.3 hours
DVD-3	80 mm	2	1	2.72 Gb = 2720 Mb	about 1.4 hours
DVD-4	80 mm	2	2	4.95 Gb = 4950 Mb	about 2.5 hours
DVD-5	120 mm	1	1	4.37 Gb = 4370 Mb	about 2.25 hours
DVD-9	120 mm	1	2	7.95 Gb = 7950 Mb	about 4 hours
DVD-10	120 mm	2	1	8.74 Gb = 8740 Mb	about 4.5 hours
DVD-14	120 mm	2	2 on bottom disc 1 on top disc	12.32 Gb = 12,320 Mb	about 6.5 hours
DVD-18	120 mm	2	2	15.90 Gb = 15,900 Mb	about 8 hours

- Notes:
- 1) The chart above applies to molded discs only. For capacity of shaped or cut discs, refer to the Cut/Shaped CD Capacity Chart.
  - 2) All of the above discs are 1.2 mm thick, have a 15mm diameter center hole, and physically will fit in the same jewel boxes and DVD player trays.
  - 3) Both CDs and DVDs are played back by a laser through the bottom surface of the disc.
  - 4) All CD's are one 1.2 mm thick molded disc, with the data on the top surface.
  - 5) All DVDs are two 0.6 mm thick molded discs with the data sides glued together to make a 1.2 mm thick disc, with the data in the center.
  - 6) All 2 sided discs cannot be screen printed over the whole the top surface. They can have screen print only within the stacking ring diameter.



# Optical Disc Production

- 1) Customer Master Transfer.
- 2) Glass Mastering.
- 3) Stamper Electroforming.
- 4) Injection Molding.
- 5) Metalizing.
- 6) Lacquering.
- 7) UV Curing.
- 8) Inspection.
- 9) Decoration



# Customer Master Transfer

- CD/DVD
- CD-R/DVD-R
- Exabyte 8mm tape
- DLT
- Analog Tape
- Sony 1630 U-Matic
- USB Drive
- FTP



DDP  
Files

# DDP Files

- DDP = Disc Description Protocol
- DDP files are the native file format of Laser Beam Recorders.
- Files contain:
  - Raw binary user data files.
  - Some physical DVD disc parameters.
  - Disc data type (CD-DA/ROM/DVD-Video...).
  - Track location info.

# DDP Files

- Why DDP, why not ISO?
- DDP describes a physical disc layout.
- ISO describes a data set only.
- DDP files tell LBRs a complete description of target disc, removing almost all sources of error in formatting at the plant.
- DDPs can be stored and delivered on any media.
- ISO files do not even have to describe whether the volume is a CD or DVD.
- Many versions of ISO files, only one DDP definition.

# DDP Files

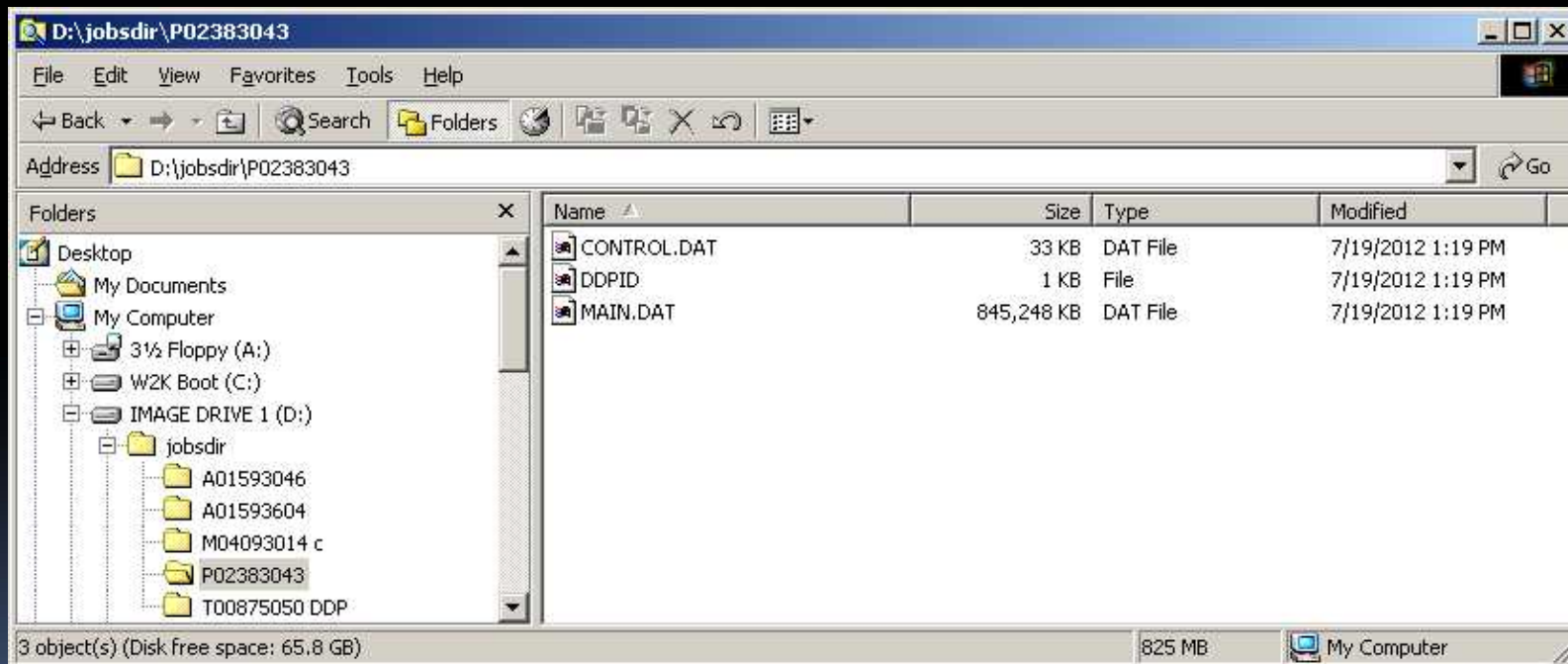
- Typical CD DDP Files:

The screenshot shows a Windows Explorer window titled "D:\jobdir\A01593046". The address bar shows the path "D:\jobdir\A01593046". The left pane shows the folder structure, with "A01593046" selected under "IMAGE DRIVE 1 (D:)". The right pane displays a list of files with columns for Name, Size, Type, and Modified. The status bar at the bottom indicates "7 object(s) (Disk free space: 65.8 GB)" and "545 MB" of free space.

Name	Size	Type	Modified
DDPID	1 KB	File	7/25/2012 3:27 PM
DDPMS	1 KB	File	7/25/2012 3:27 PM
DDPPQ	1 KB	File	7/25/2012 3:27 PM
IC01.TRK	130,578 KB	TRK File	7/25/2012 3:17 PM
IC02.TRK	131,085 KB	TRK File	7/25/2012 3:20 PM
IC03.TRK	128,527 KB	TRK File	7/25/2012 3:23 PM
IC04.TRK	168,132 KB	TRK File	7/25/2012 3:27 PM

# DDP Files

- Typical DVD DDP Files:



# Glass Preparation

- ODC LaserPrep
- Strip remnants from previous use.
- Cleaning.
- Dye polymer coating.
- Baking.



# Glass Mastering

- Laser Beam Recorder (LBR)
- ODC Laserwave II.
- Solid-state 422 nM laser.
- DRAW (Direct Read After Write) allows for on-the-fly waveform correction, compensating for glass coating non-uniformity.



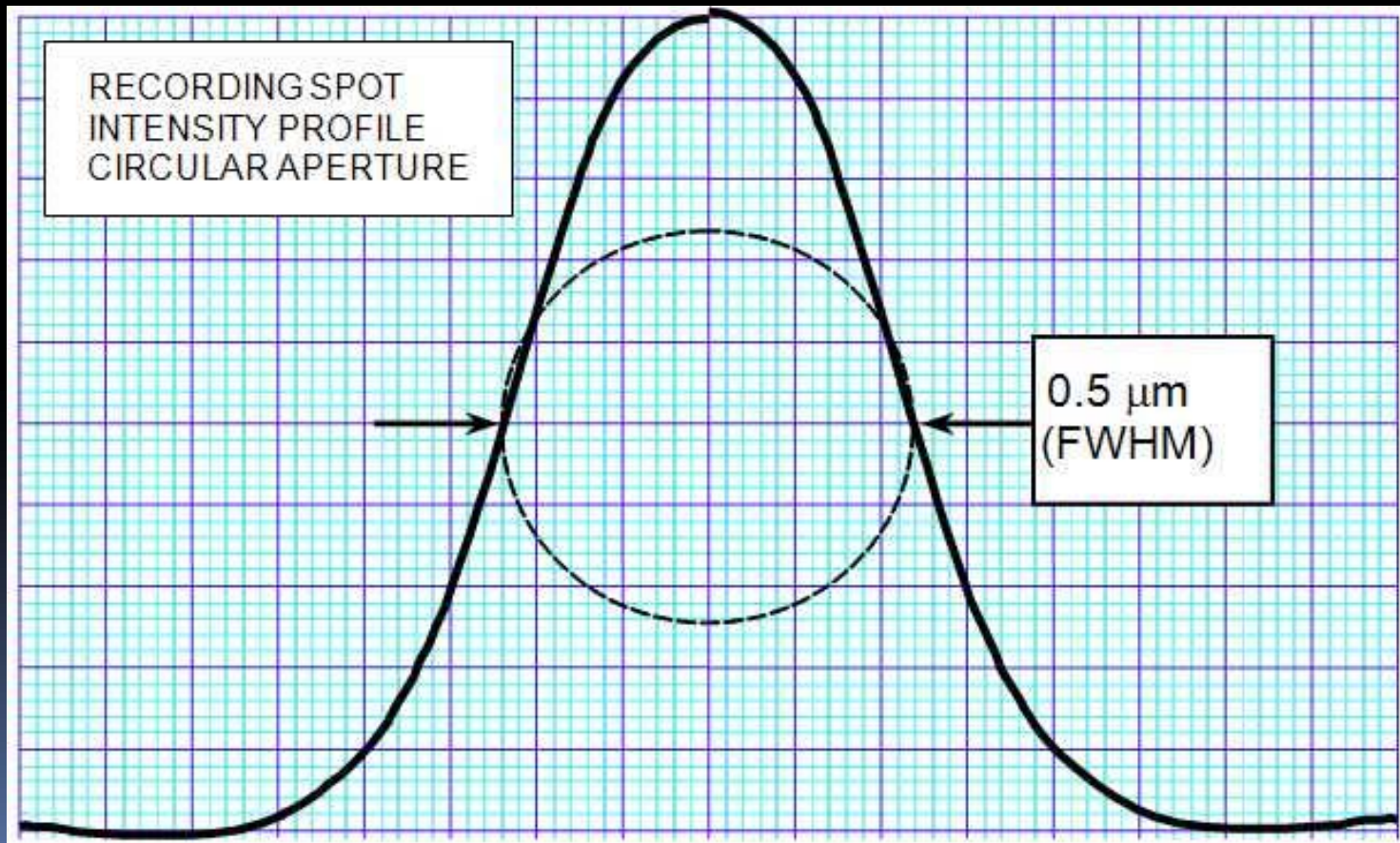


# Glass Mastering

- DDP parameters determine LBR Data Formatting.
- Data converted from serial bitstream to EFM (Eight of Fourteen Modulation) pulse stream.
- EFM Waveshaping determines final physical pit shape, which determines electro-optical performance in playback.

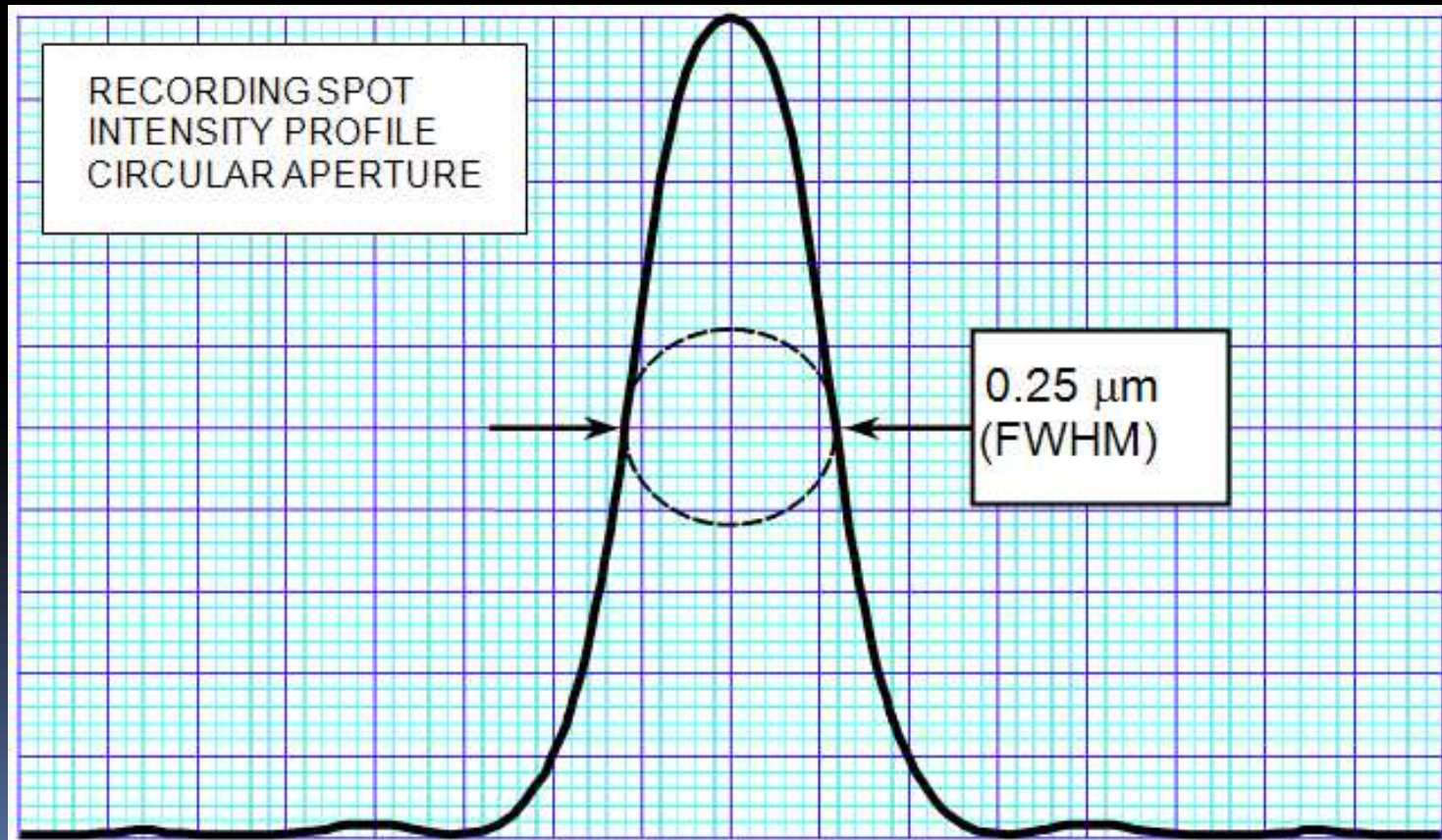
# Laser Beam Recording

- CD Laser beam profile ( $488\text{nm } \lambda$ )



# Laser Beam Recording

- DVD Laser beam profile ( $422\text{nm } \lambda$ )



# Metalization

- Creates electrically conductive layer on glass master.
- CHA - SEC600rap
- Evaporative nickel coating directly on pit & land surfaces.
- 60 minute cycle time/3 parts.



# Metalization

- Planetary fixturing for even deposition.
- Simultaneous 3-substrate metalize.
- Evaporative nickel source.
- 600 Å deposition.



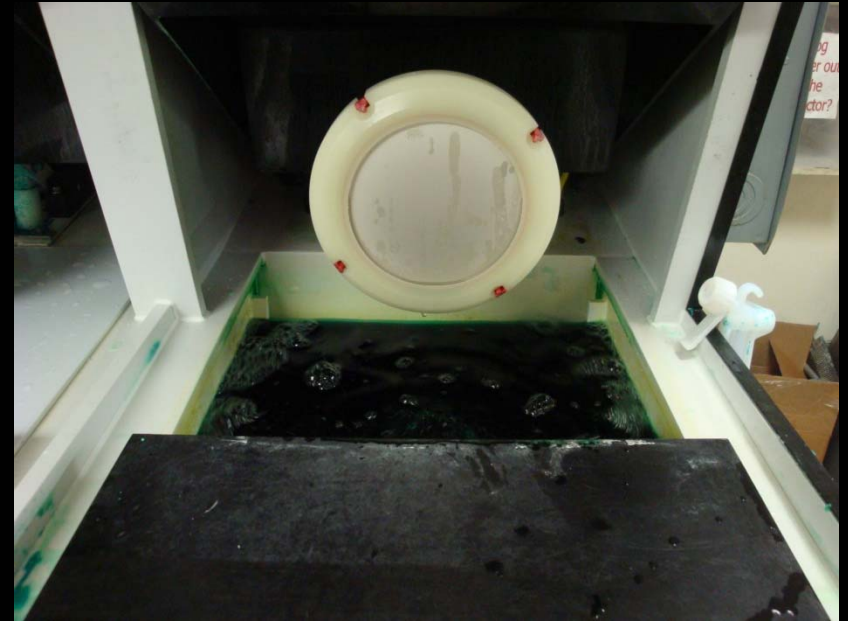
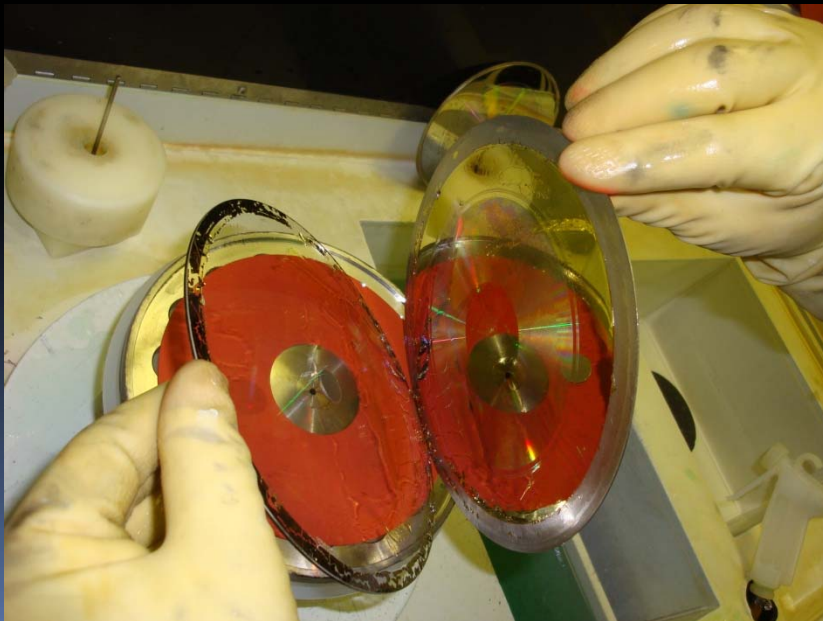
# Electroforming

- Nickel sulfamate wet process electroforming.
- 300  $\mu\text{M}$  of nickel.
- 45 minute process.



# Electroforming

- Electroformed stamper on fixture just out of bath.



- Stamper being separated from glass.

# Stamper Back-sanding

- Back side sanding.
- Removes small nodules.
- Leaves smooth surface.
- Allows even flow of air to ensure vacuum hold in mold.





# Stamper Punching

- Precision ID and OD punching.
- ID fits mold with  $<2 \mu\text{M}$  clearance to inhibit plastic extrusion between stamper and mold.



# Stamper Finishing

- Silitect protective coating applied on spin coater.
- Thickness tested and recorded.
- Finished stamper sent to molding.



# CD Molding

- 120mm CD mold.
- <3 second cycle time.



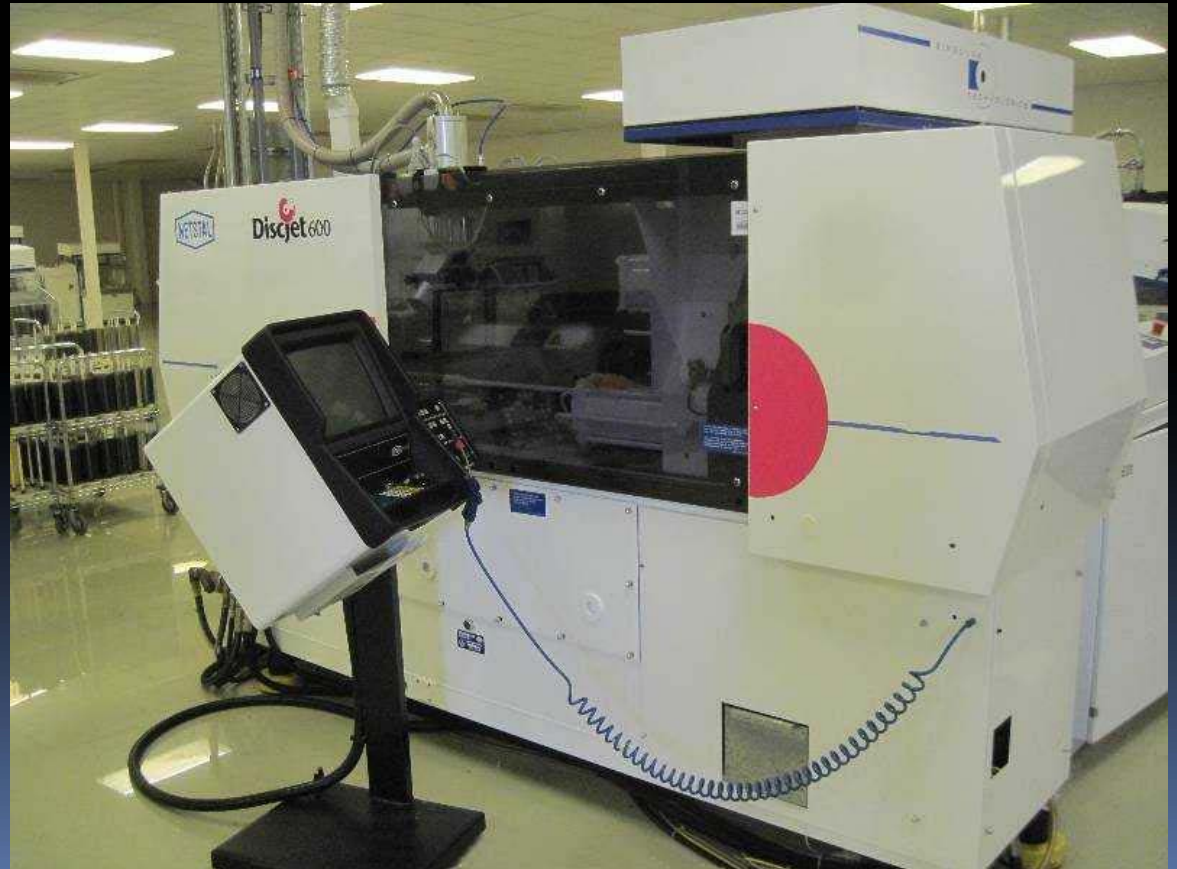
# CD Molding

- Netstal DiscJet Hydraulic Injection Molding Machine (IMM).



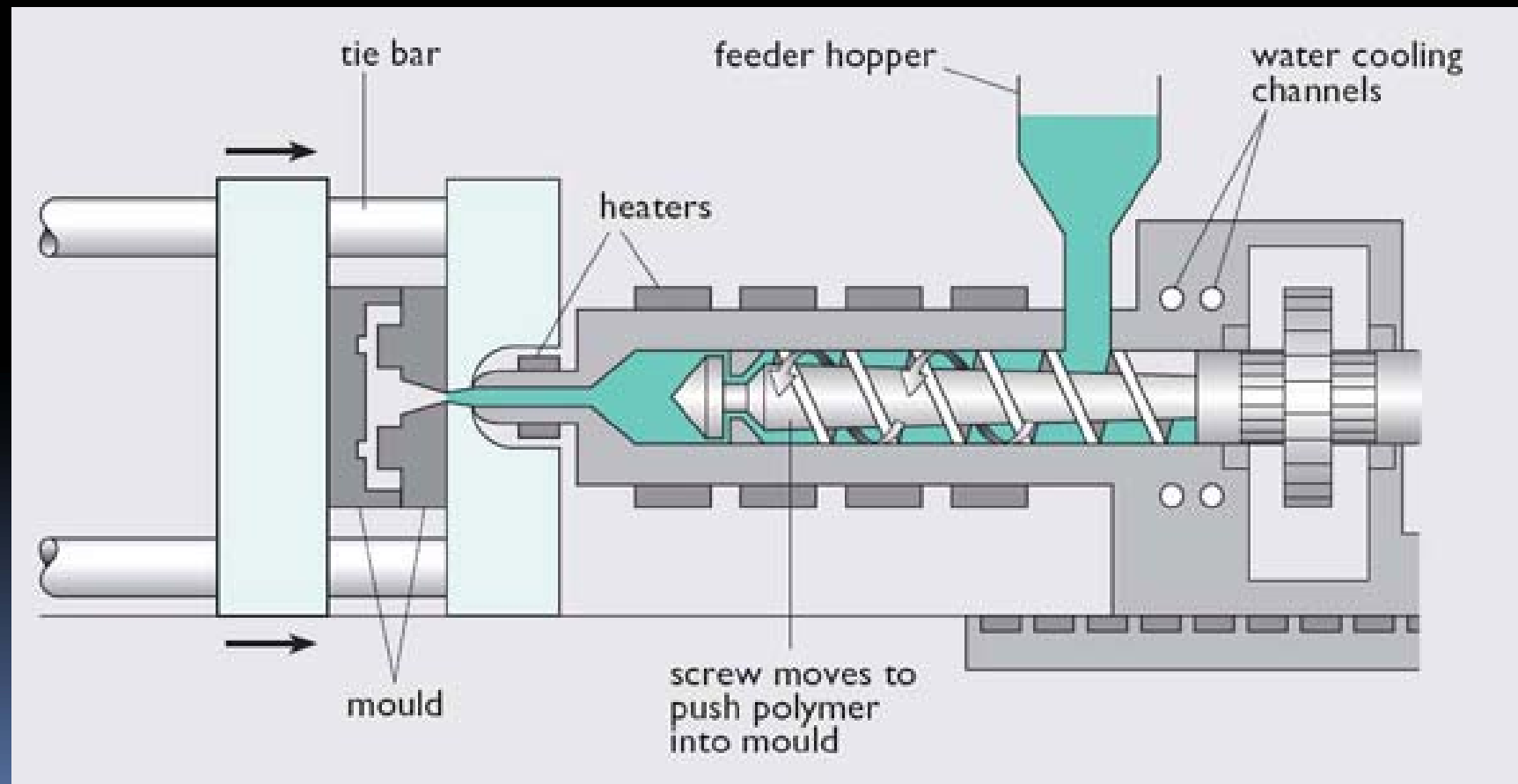
# CD Molding

- DSP process control.
- Cycle steps:
  - Metering.
  - Plasticising.
  - Injecting.
  - Holding.
  - Demolding.



# CD Molding

- Injection Molding Machine (IMM) diagram

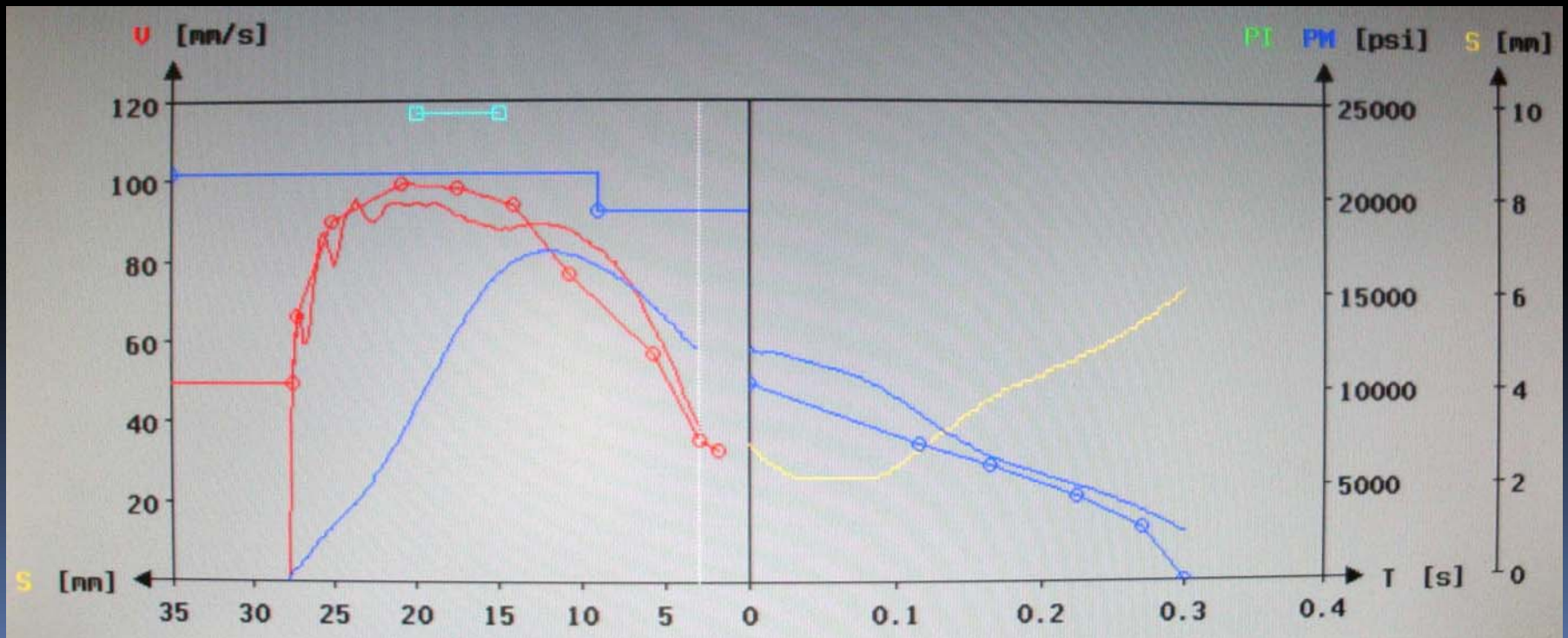


# CD Molding

- Cycle steps:
  - Metering & Plasticising: in the injection barrel, the screw (acting like an Archimedian Screw with a tapered root) spins to move pellets toward the nozzle into a steadily decreasing space. This causes them to compress and melt due to the heat of molecular shearing.
  - The heat that melts the plastic is NOT externally applied by heaters, it is developed inside the plastic pellet itself.
  - This ensures even heat distribution throughout the melt from the start of the process. External heater bands merely keep the melt at the proper temperature.
  - As the melt accumulates at the end of the screw, it pushes the screw back by hydraulic force. The IMM knows how much plastic is in a shot by the amount the screw has metered back from its fully forward injection position.

# CD Molding

- Cycle steps:
  - Injection and Holding: The screw pushes plastic into the mold, servoing for velocity in **RED** until the cavity is full at position "o" called V-P changeover.
  - The IMM then servo for cavity pressure in **BLUE** to keep the disc density and pit quality as the plastic shrinks in the mold.

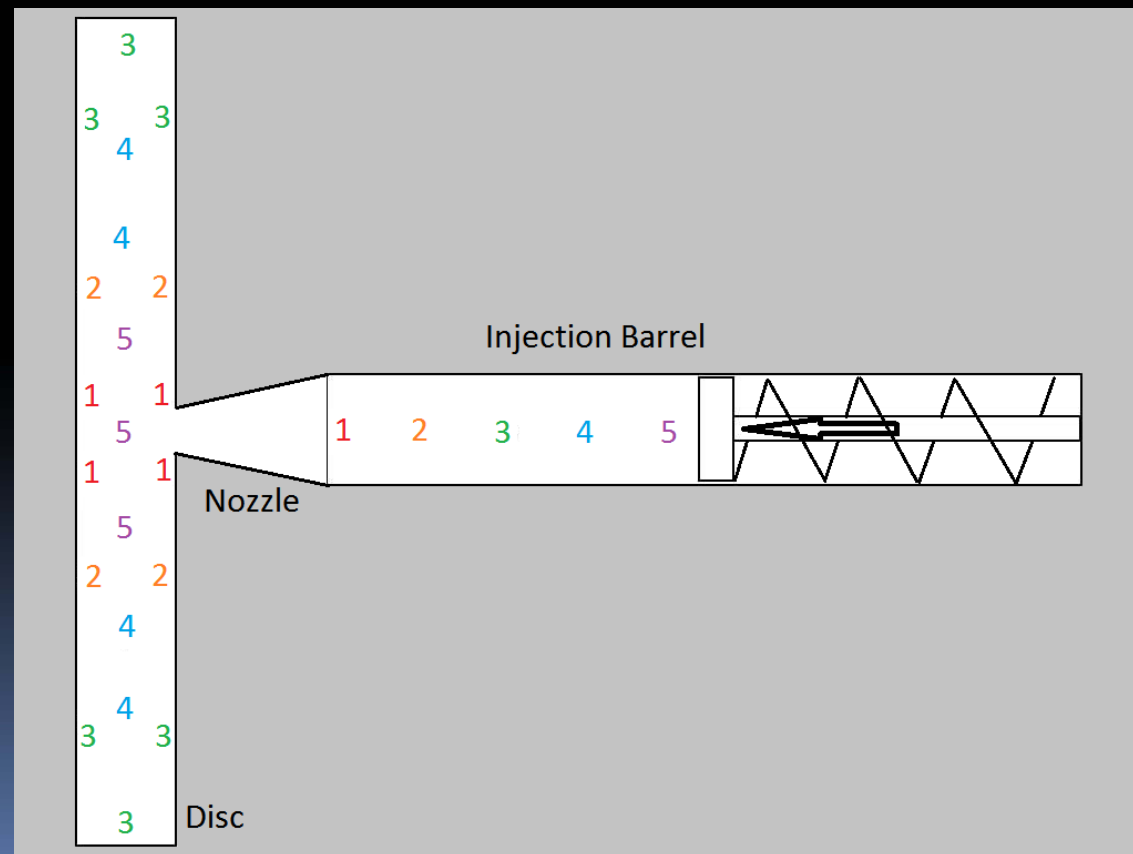




# CD Molding

Fountain Filling Model:

First plastic from nozzle (1) freezes against the relatively cold mold surface and forms the skin at the center of the disc. As screw pushes forward plastic flows radially into the cavity. Last plastic (5) in forms the center core.

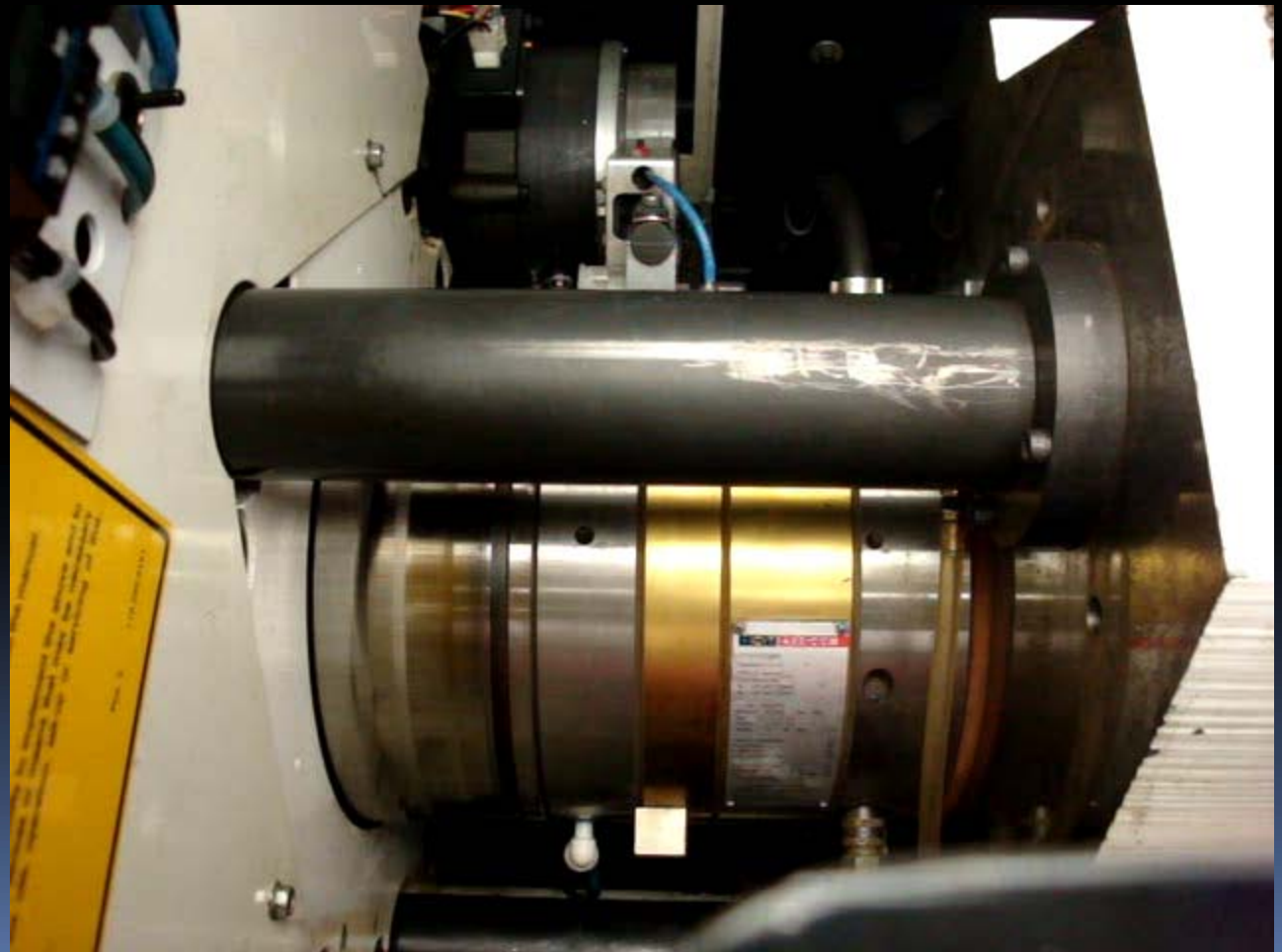


# CD Molding

- Cycle steps:
  - Demolding. Air is injected on either side of the disc to separate it from the mold's surface as the mold opens. A high-speed robot then removes the disc from the mold cavity.
  - The disc is taken out with the core still liquid, due to extreme ratio of surface area to volume, cooling is rapid.
  - Rinse, Lather, Repeat: 1.5 billion times.

# CD Molding

- Complete Cycle:



# CD Substrate Cooling



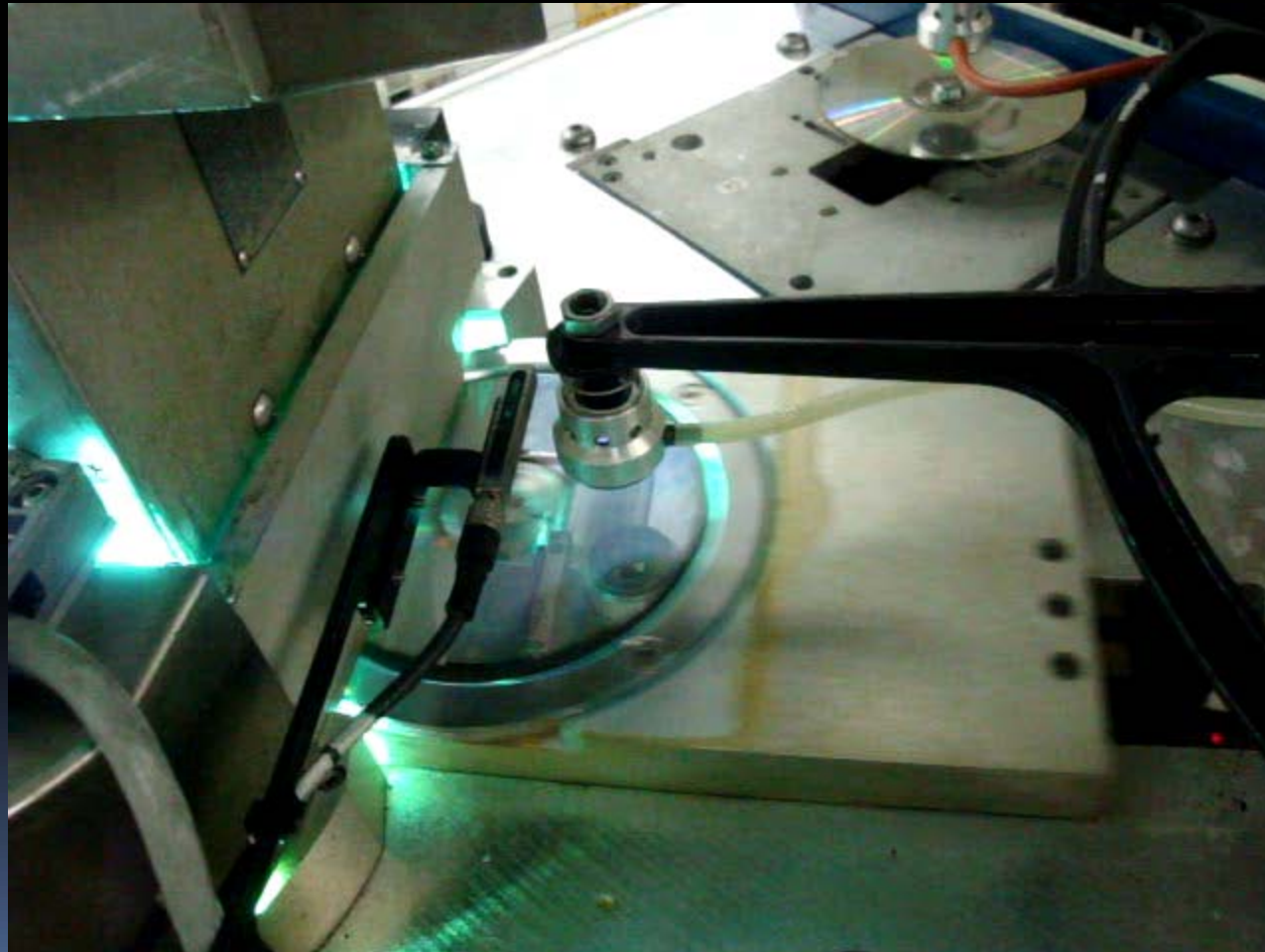
# CD Metalizing



# CD Spin Coating

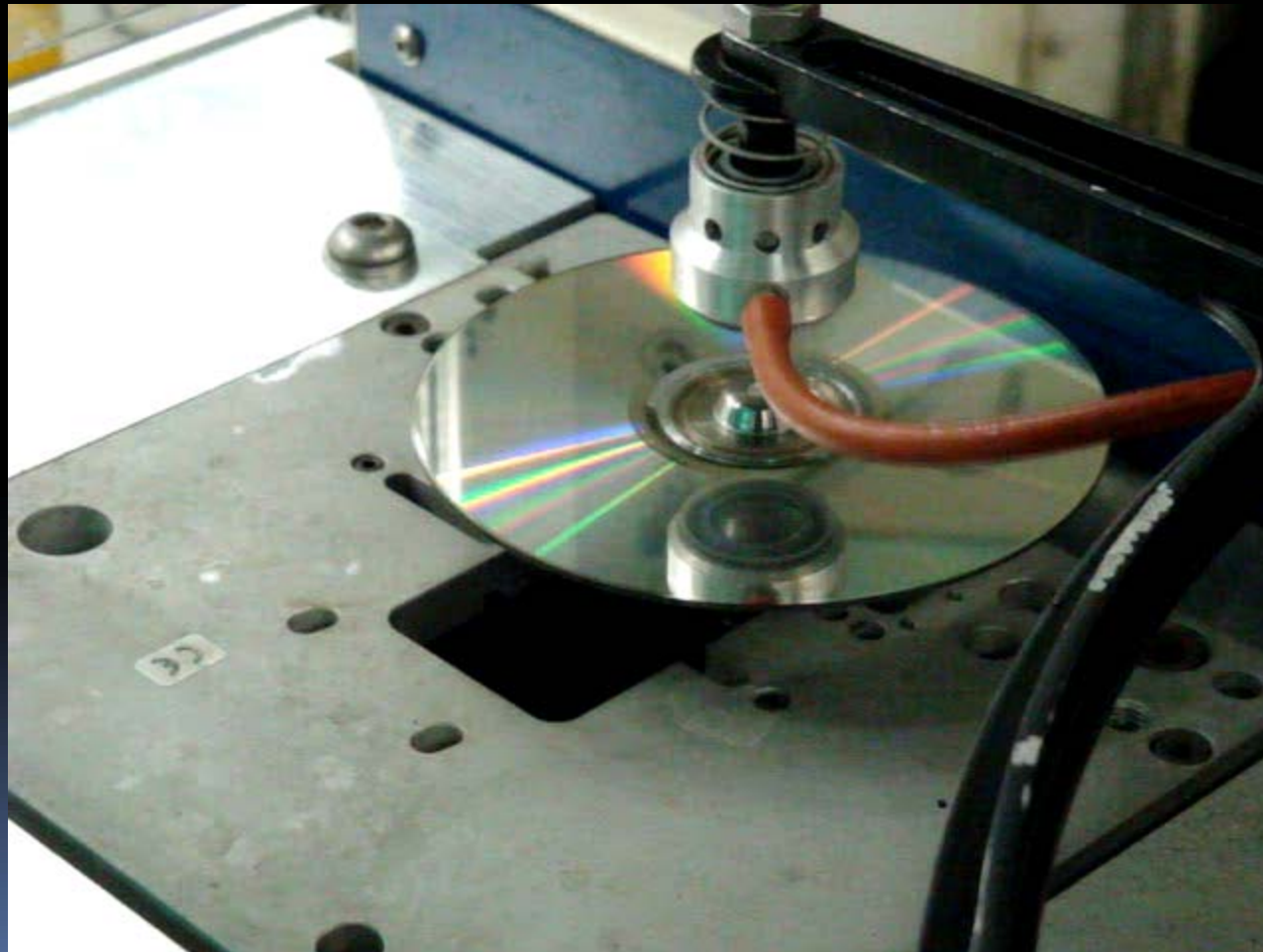


# CD UV Curing



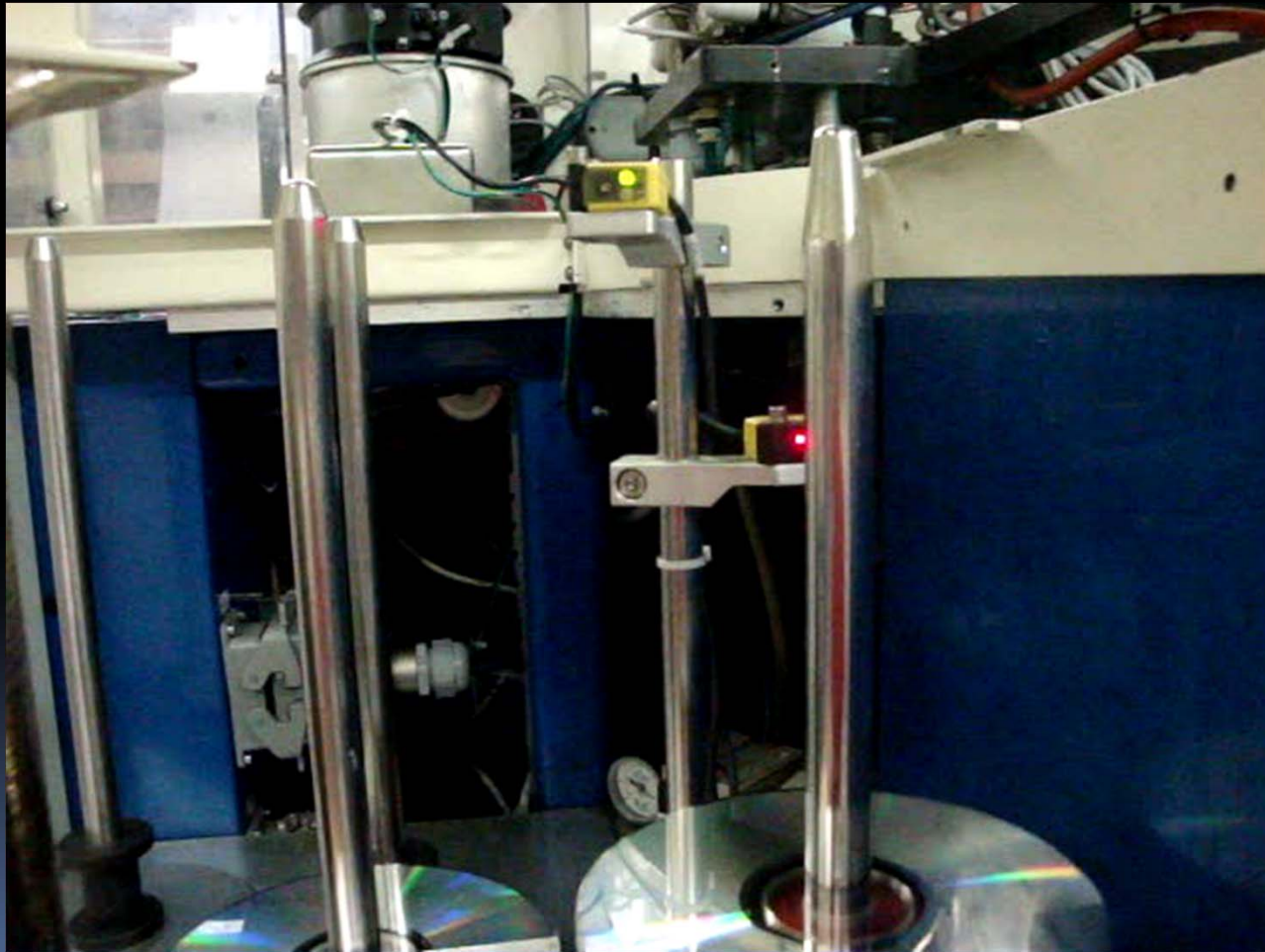
# CD In-Line Inspection

- Detects physical obstructions to data recovery.





# CD Spindlizing



# CD Off-Line Testing

CD CATS SA 3 (C) Copyright 1992-1999  
AUDIO DEVELOPMENT INFORMATIONSTEKNIK AB SWEDEN, All Rights Reserved. Ver.:3.80

Production name: Mondo-Tech MT-0012-101  
Production number:  
Produced by: Audio Development AB  
Test type: Complete  
Tested by: SUP, Test date: 2001-02-23 10:03:07  
Disc type:CD-ROM., Tracks:1, Limits applied:CD-ROM  
Total playing time: 74:04  
Players: 3:S542

STATIC DATA		VERTICAL DATA		MIN	MAX	AVG
SLD:	45.61	DEV:		-0.01	0.12	0.044
SPD:	49.87	DEFL:		0.0	0.3	0.12
MID:	113.9	PP:		0.049	0.053	0.0512
SVY:	1.40	PPC:		0.045	0.050	0.0484
TRP:	1.61	XT:		22	26	23.7
ECC:	18	SVY:		1.40	1.41	1.404
		TRP:		1.60	1.62	1.608

## TEST DATA

MIN	AT	MAX	AT	AVG
BLER:	0	00 10 01	29	00 42 01 3.5
E11:	0	00 10 01	231	17 43 04 3.1
E21:	0	00 06 04	10	09 19 04 0.2
E31:	0	00 06 04	27	00 42 01 0.2
E12:	0	00 06 04	416	00 42 01 1.0
E22:	0	00 06 04	0	00 00 00 0.0
E32:	0	00 06 04	0	00 00 00 0.0
I3:	0.54	13 28 01	0.57	00 06 04 0.549
I11:	0.79	53 53 01	0.84	00 06 04 0.809
I3R:	0.54	13 28 01	0.57	00 06 04 0.549
I11R:	0.79	53 53 01	0.84	00 06 04 0.809
REF :	74	54 48 01	77	23 28 01 75.9
SYM :	1	00 06 04	2	34 06 01 1.7
BERL :	0	00 06 04	5	00 42 01 0.0
CRC:	0	00 06 04	3	00 42 01 0.0
RN :	6	40 42 04	21	42 46 04 10.2

BEGL : 0 E32TOT : 0

## Time Interval DATA

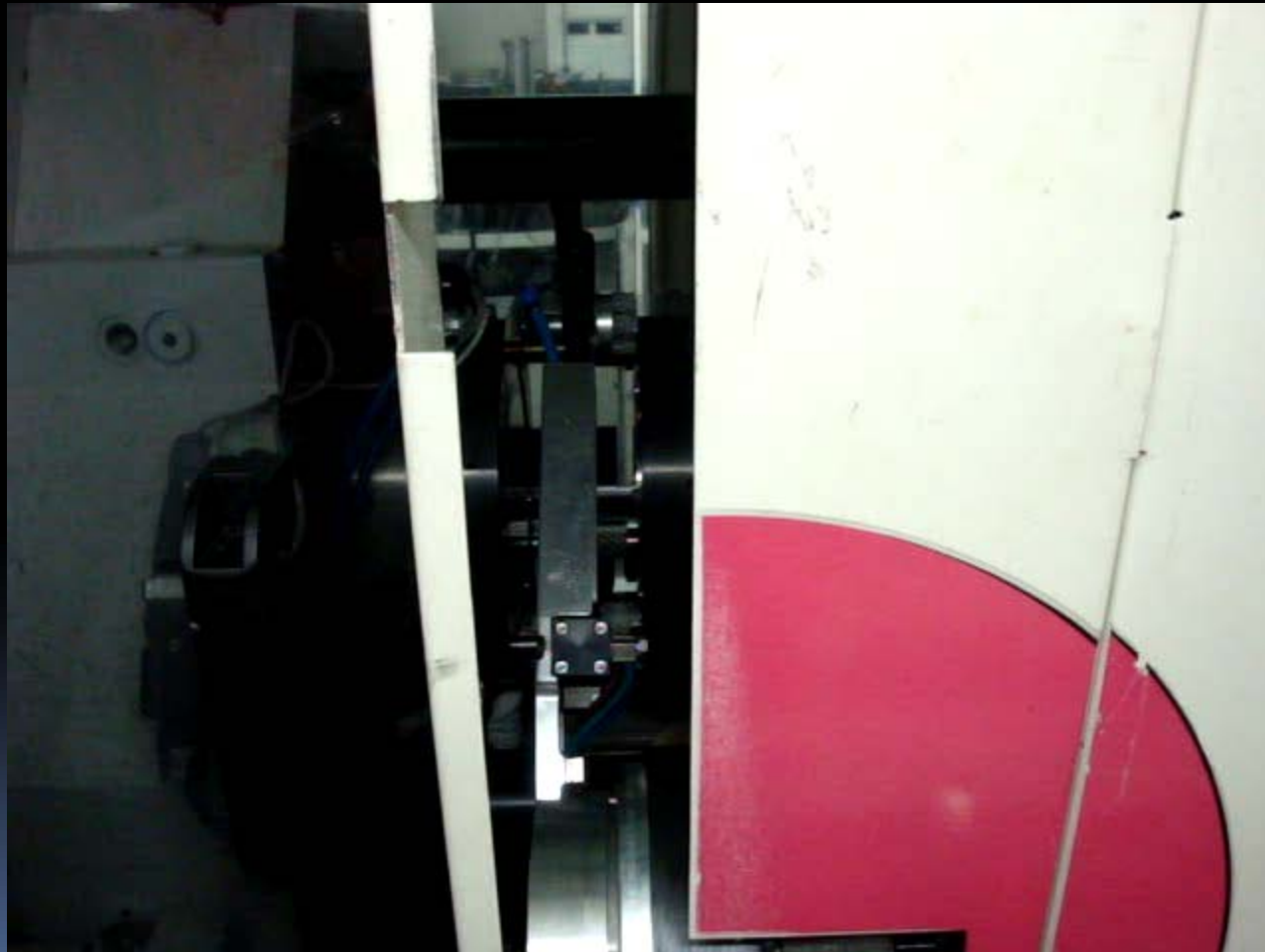
### Length deviation avg:

	3T	4T	5T	6T	7T	8T	9T	10T	11T
Land:	-7	1	7	6	8	9	7	8	0
Pit :	-24	-20	7	13	12	18	20	21	21

### Utter avg:

	3T	4T	5T	6T	7T	8T	9T	10T	11T
Land:	24	25	23	22	21	21	20	21	18
Pit :	17	18	16	16	16	15	15	15	15

# DVD Molding



# DVD Substrate Cooling



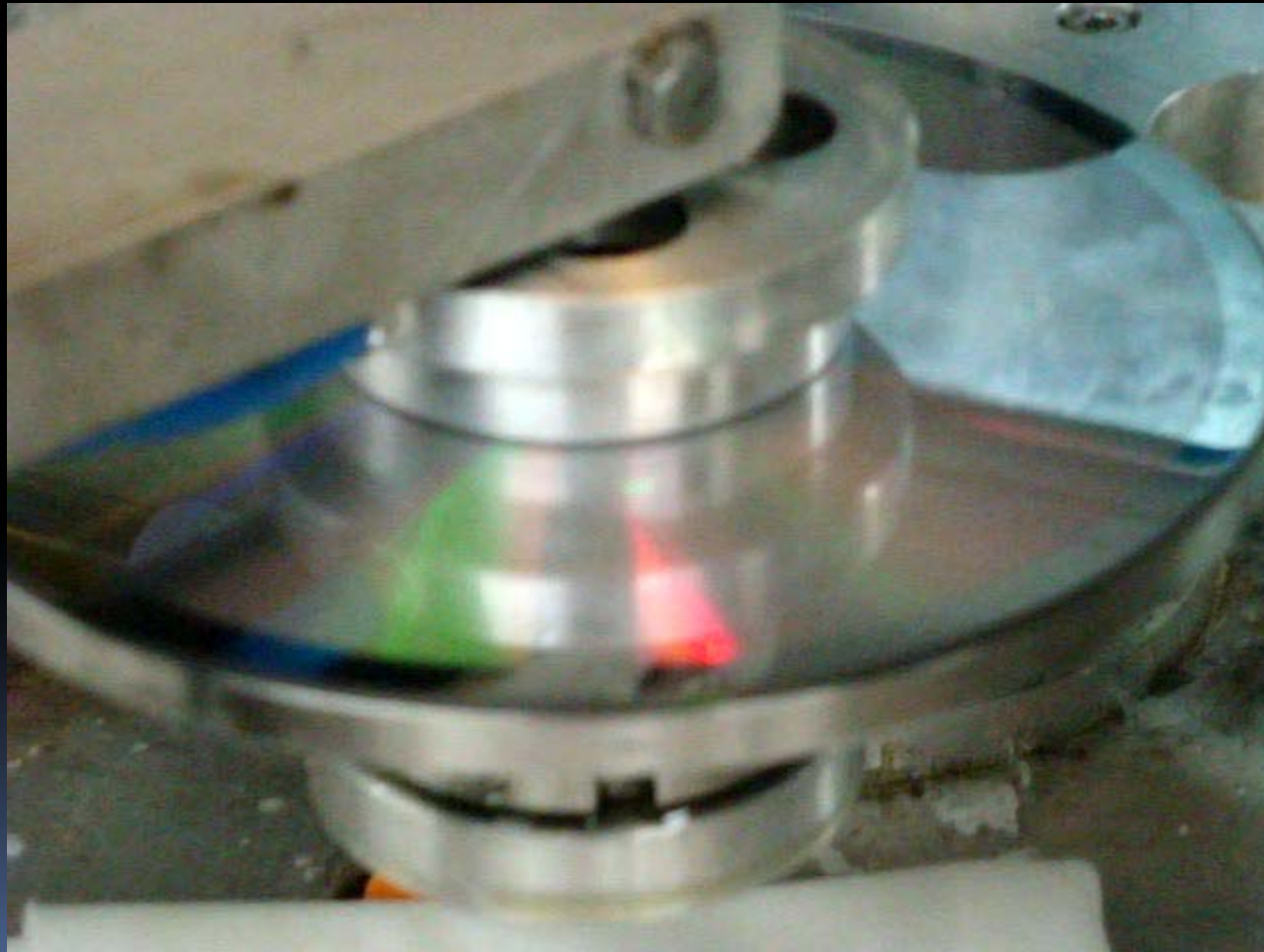
# DVD Metalizing



# DVD Bond Dispense & Turn-over



# DVD Bonding



# DVD Leveling, Curing & In-Line Inspection





# DVD Off-Line Testing

## AMI DVD TEST REPORT

**CATS**

www.audiodev.com/testresult

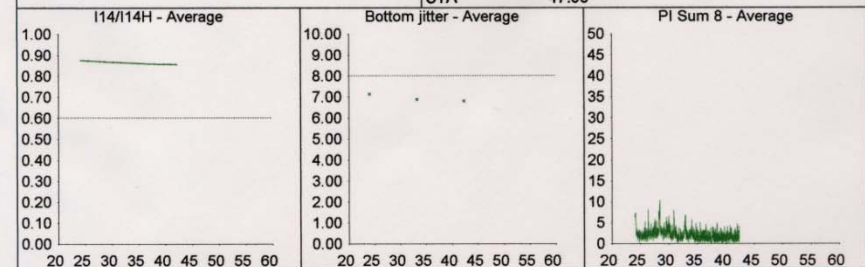
**PASS**

Production Name: VR2104-3 NOW  
 Production Number:  
 Module(s): 1 - DPE513  
 Module Type(s): Pulsotec DVD  
 Test Template: AMI Complete DVD  
 Test Result: **PASS**

Operator: DLO  
 Date: 11/19/04  
 Time: 10:35:57 AM

Parameter	Min	Max	Avg	Lower	Upper	Parameter	Min	Max	Avg	Lower	Upper
RN	4.95	6.76	5.739			I14H LV		0.14			
SVY	3.470	3.476	3.4741	3.4510	3.5240	I14H RV	0.0	0.1	0.03	0.00	0.15
PIE	0	4	0.2			I14H DV		0.14		0.000	0.330
POF	0	0	0.0	0.0	0.0	TCS	0.29	0.32	0.302	0.100	1.000
PIF	0	2	0.0			DPD Amp	0.79	0.82	0.808	0.500	1.100
PI Sum 8	0	13	2.0	0.0	280.0	DPD Asym	0.000	0.000	0.0002	0.0000	0.2000
I3/I14	0.25	0.26	0.258	0.150	1.000	RRO	19	23	20.2	0.0	100.0
I14/I14H	0.85	0.88	0.861	0.600	1.000	DC Jitter	7.09	7.25	7.155		
ASYM	8.693	10.203	9.2833	-5.0000	15.0000	DC Neg Jitter	6.92	7.15	7.010		
R14H	49.98	58.10	55.378	45.000	85.000	DC Pos Jitter	7.03	7.17	7.082		
TPP	0.092	0.146	0.1075	0.0000	0.9000	Bottom jitter	6.78	7.11	6.923	0.000	8.000
FE	0.026	0.238	0.0453			I14H DV2	0.07	0.19	0.150	0.000	0.330
Radial1	3.62	10.64	6.156								
Radial2	4.82	6.57	5.580	0.000	16.000						
Beta	0.02	0.03	0.024								

Physical	Layer 0	Limit 0	Limit 1
LLO	32.86		
TRP	0.737	0.7300-0.7500	0.7300-0.7500
ODIA	117.16	86.30-	70.00-
IDIA	44.26	0.000-45.200	0.000-45.200
ODDA	84.30	0.000-116.000	0.000-116.000
IDDA	47.80	47.600-48.050	47.600-48.050
STA	47.58		



# Substrate Physical Testing

- Characterizes:
  - CD/DVD Clear discs.
  - Metalized discs.
  - CD lacquer
  - DVD Bond Layer.



# Substrate Physical Testing

		CD/CD-R/ CD-RW	DVD-5/-10	DVD-9/ -14/-18	DVD±R
<b>Basic System Measurement Channels</b>					
PROmeteus MT-200	<ul style="list-style-type: none"> <li>• Transmission and Reflectivity at 650 nm</li> <li>• Radial and Tangential Deviation, Vertical Deviation</li> <li>• Vertical Runout and Axial (Vertical) Acceleration</li> <li>• Optical Density / Thickness of CD-R Dye</li> <li>• Optical Density / Thickness of Reflective Layer</li> <li>• Optical Density / Thickness of Semi-Reflective Layer</li> <li>• Birefringence Values and Orientation</li> <li>• Diffraction Efficiency: 1st Order of CD and DVD</li> <li>• Diffraction Efficiency: 2nd and -1st Order of CD</li> <li>• Groove Depth and Width for CD-R and CD-RW</li> <li>• Clouding of CD</li> </ul>	■	■	■	■
<b>Optional Measurement Channels</b>					
LAYER-THICKNESS	<ul style="list-style-type: none"> <li>• Space Layer Thickness</li> <li>• Substrate Thickness of CD and DVD</li> <li>• Space Layer plus Substrate Thickness</li> <li>• Unbalance of CD and CD-R</li> </ul>	○	○	■	○
DIFF-ORDER DVD	<ul style="list-style-type: none"> <li>• Diffraction Efficiency: 2nd and -1st Order of DVD</li> <li>• Groove Evaluation for DVD±R and DVD±RW</li> <li>• Clouding of DVD</li> <li>• Reflectivity and Transmittance at 405 nm</li> </ul>	-	○	○	▲
DVDR DYE	<ul style="list-style-type: none"> <li>• Optical Density / Thickness of DVD±R Dye</li> </ul>	○	-	-	■
DVDR DL DYE ?)	<ul style="list-style-type: none"> <li>• Optical Density / Thickness of DVD±R Dye and DVD±R DL Dye</li> </ul>	○	-	-	○
HIGH-RES ACC	<ul style="list-style-type: none"> <li>• Enhanced Evaluation of Local Deformations (ACC)</li> </ul>	○	○	○	▲
PERP-BIREF	<ul style="list-style-type: none"> <li>• Perpendicular Birefringence</li> </ul>	○	○	○	○
LACQUER	<ul style="list-style-type: none"> <li>• Measurement of Lacquer Thickness</li> </ul>	▲	-	-	○
LAPTOP	<ul style="list-style-type: none"> <li>• Laptop for Data Storage</li> </ul>	○	○	○	○
STAMPER	<ul style="list-style-type: none"> <li>• Stamper Adapter, Stamper Pin, Diameter on Request</li> </ul>	-	-	-	-

# Replica Data Verification

- Full User & Subchannel data verification.
- Compare any source media to any replica.

