



SMART SOLUTIONS TO DRIVE THE FUTURE

Blu-ray Disc

Inline Production with BLU-LINE

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Agenda

- 1- Introduction**
- 2- Mile Stones**
- 3- Replication Process Steps**
- 4- Cover Layer Technology**
- 5- Film Bonding Technology**
- 6- Liquid Resin Technology**
- 7- Humidity Change**
- 8- Dual Layer Technology**
- 9- BLU-LINE Options**
- 10- Machine Characteristics**
- 11- What's the Future**



Blu-ray Disc – Machine Design Objectives:

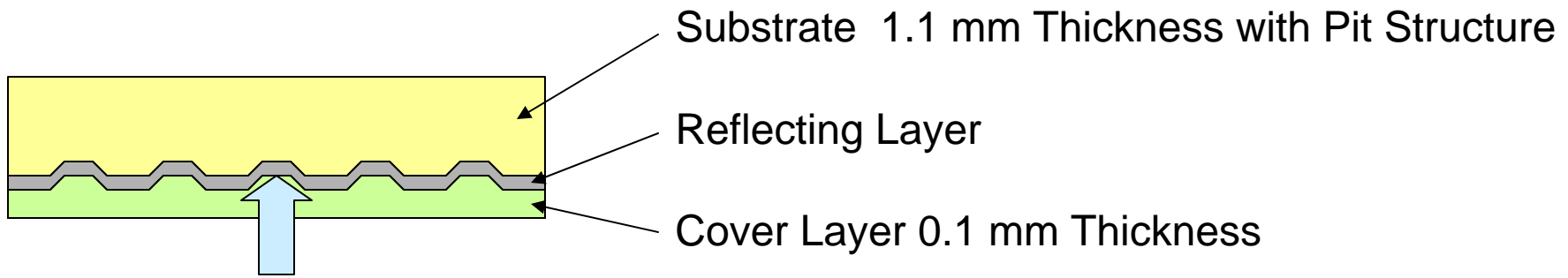
- **The Blu-ray Machine is a New Design**
- **First Generation System is a Modular Design Type**
- **Different Process required to generate Cover-Layer**
- **Anti-Piracy Function by Marking each Disc Individually (BCA - Cutting)**
- **Barrier Coating on the label side of the disc is considered**
- **Dual-Layer Technology required**

Mile stones on the way to BLU-LINE

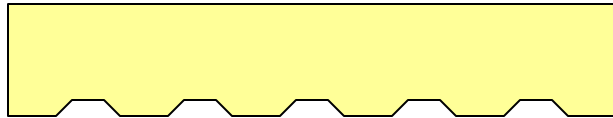
- **Summer 2004 Decision made to design a BD Line**
- **Autumn 2004 Brainstorming at R&D and Design department**
- **Winter 2004 Cooperation with SONY**
- **January 2005 BD Line named as BLU-LINE**
- **February 2005 start to build two BLU-LINE's, Film- and Spin- Technology**
- **April 28th, 2005 first play back of BD-ROM's on both technologies at SONY's BD equipment**
- **October 2005 delivery of the first BLU-LINE's to Key customers**
- **March 6th, 2006 World Premiere of the BLU-LINE**
- **July 2006 10th BLU-LINE installed**

- 3.1. Disc Structure of Blu-Ray Disc Format -

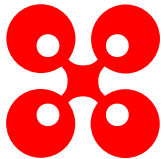
Structure of BD – Single Layer Disc



- 3.2. Replication Process Steps -



Molding of the Substrate

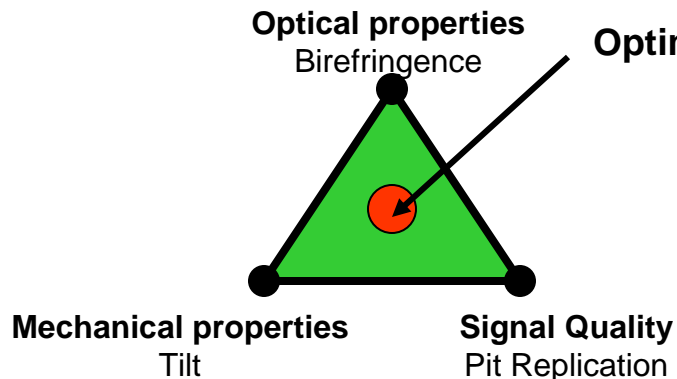


- High demand for pit replication precision
- Smaller tolerances of tilt and deviation as for DVD

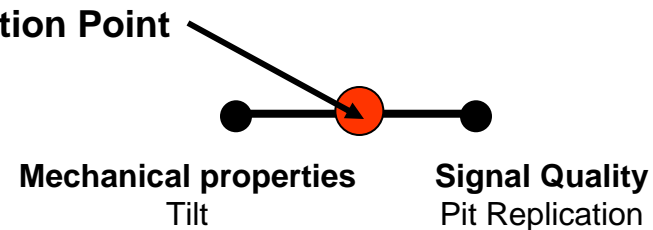


- No optical requirements to the substrate like:
 - Transparency
 - Birefringence

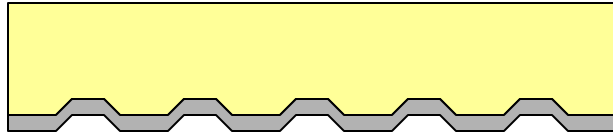
Disc Quality Triangle at DVD



Disc Quality Line at BD



- 3.3. Replication Process Steps -



Metallizing of the Substrate by Sputtering

Possible Metals:

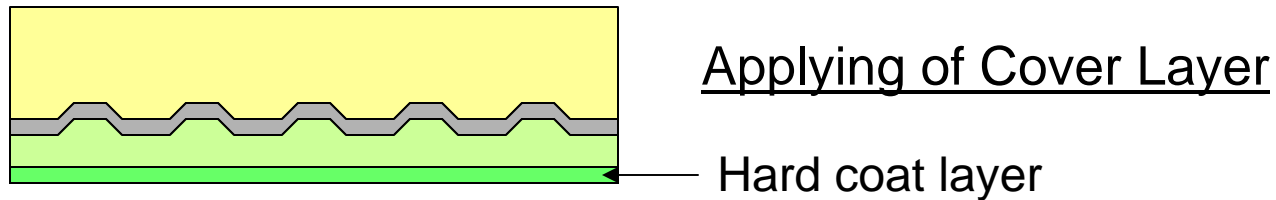
- Silver Alloy (preference)
- Aluminum

Layer thickness approx. 40 nm



Similar to DVD

- 3.4. Replication Process Steps -



Specification for cover layer: Thickness $100\mu\text{m} \pm 3\mu\text{m}$ including hard coat

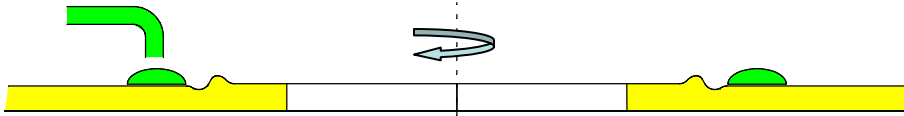
Two methods are used to create the cover layer:

- 1) Film bonding technology
- 2) Liquid resin technology

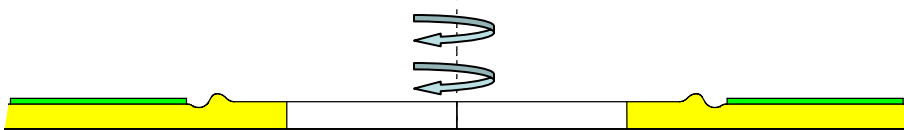
It is general sense that a BD-disc requires a more scratch resistant read side surface than a DVD or CD.

As a result, an additional hard coat shall be applied for surface protection.

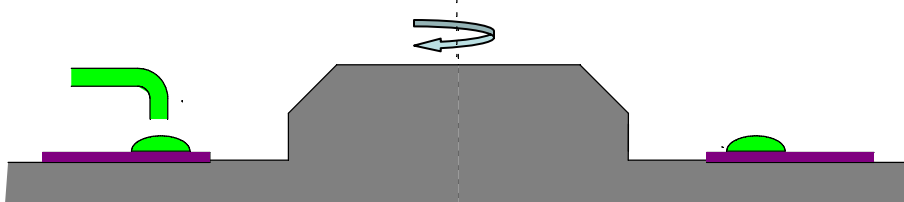
- 4.2. Film Bonding Process -



Lacquer dispense on substrate



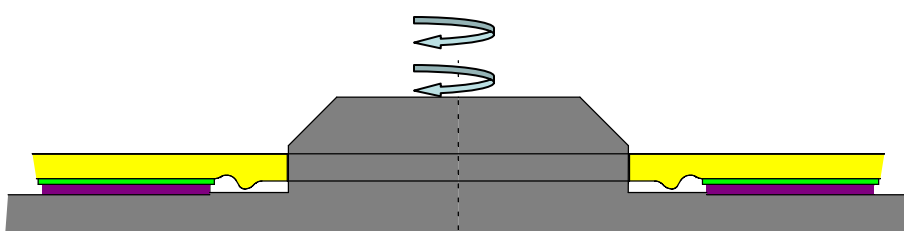
Lacquer spinning on substrate



Lacquer dispense on film with carrier



Substrate contact and approach



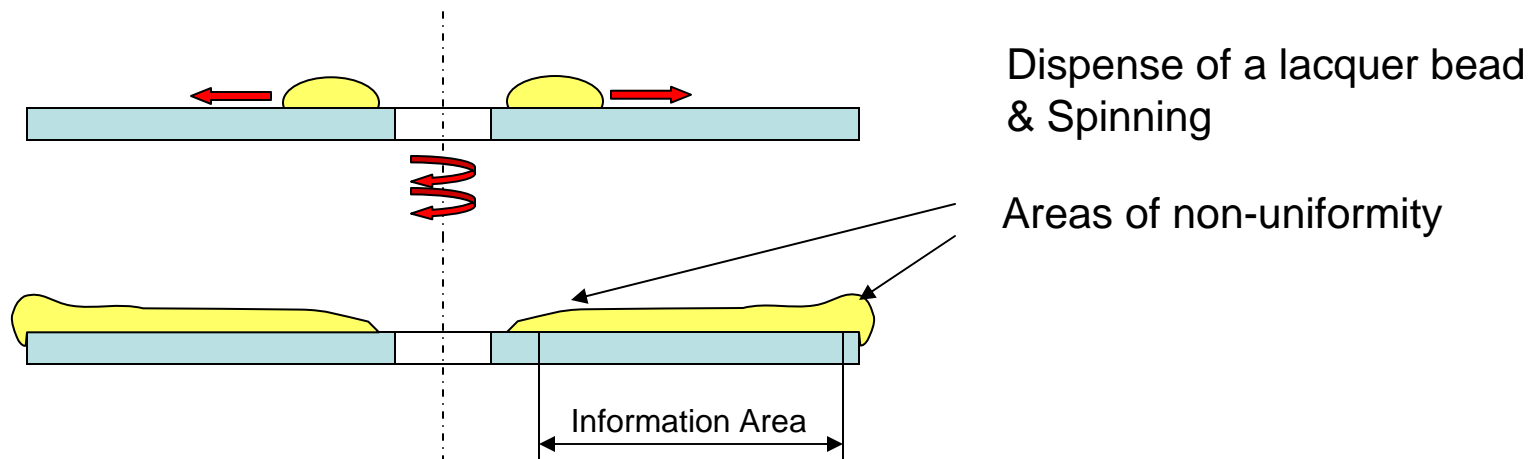
Final spinning process

Application of Cover Layer by Liquid Resin Technology

Several spin-coating technologies have been developed to achieve the required cover layer thickness uniformity

Two major issues need to be prevented in spinning process:

- Steep increase of resin thickness at inner diameter
- Formation of resin bump at outer edge of disc (ski jump)



Film Bonding vs Liquid Resin Technology

What is the most advanced process?

Criteria: - Quality of Disc
- Manufacturing Cost

Film Bonding:

- Quality of film is extremely important for final disc quality
- Cutting or punching of film could generate particles
- Solvent casting and PSA film is expensive
- Extruded film is available to reduce material cost significantly

Resin Process:

- Resin with low shrinkage required
- Process is sensitive to viscosity of the resin
- Split of the substrate flow into several spin bowls necessary (cycle time)
- No punching unit required
- Possibly most cost effective process

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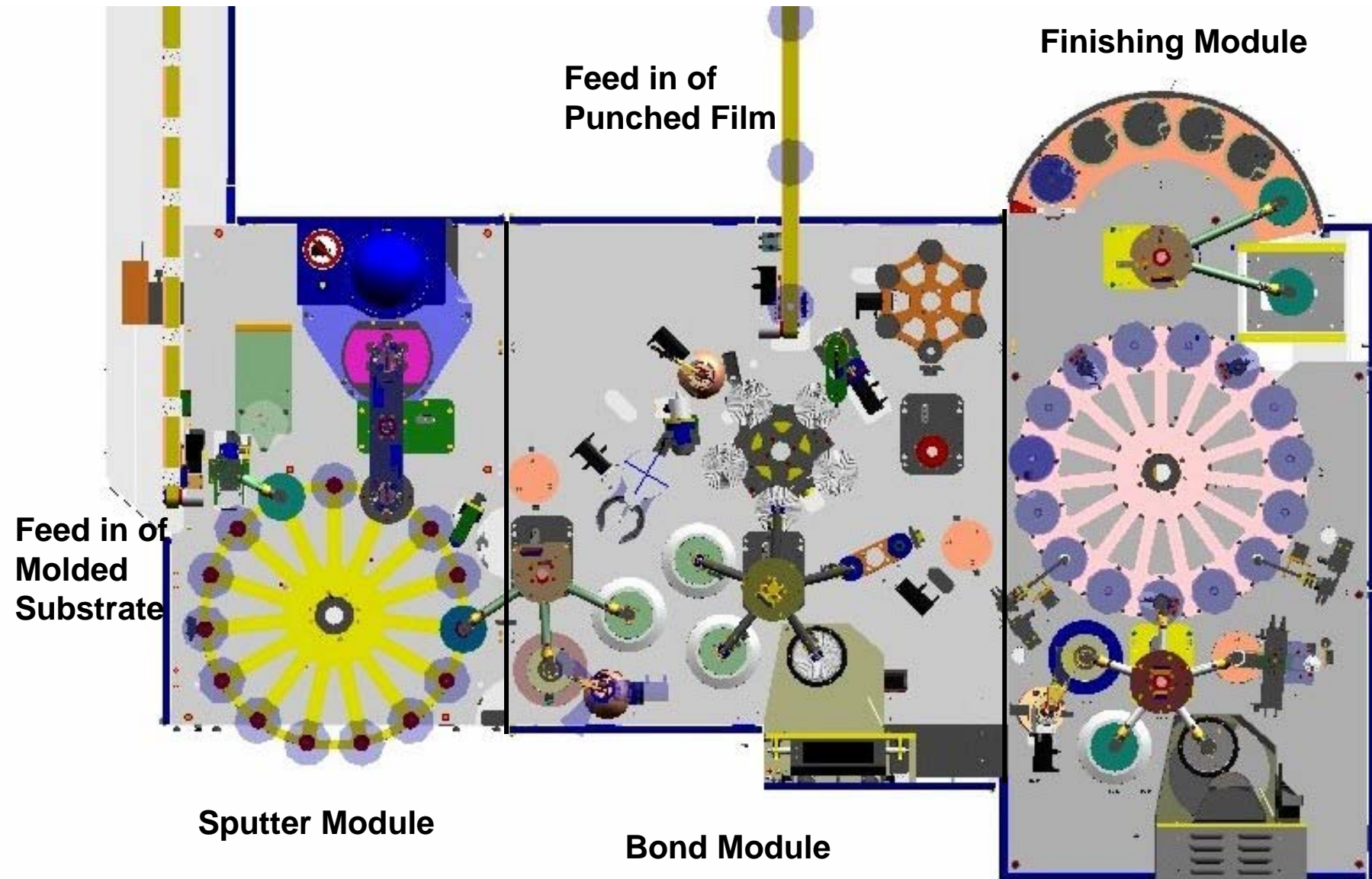
- 5.1. Film Bonding Technology -

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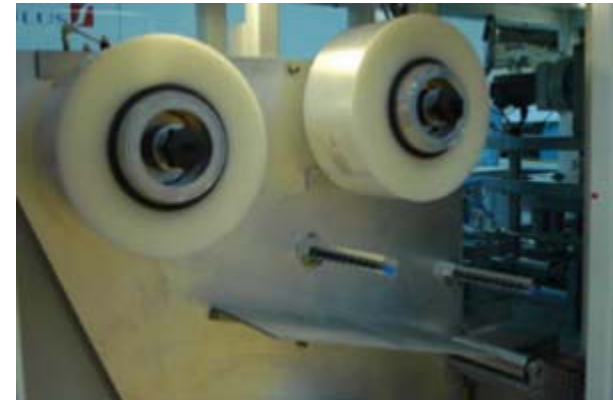
October 10th, 2006

- 13 -

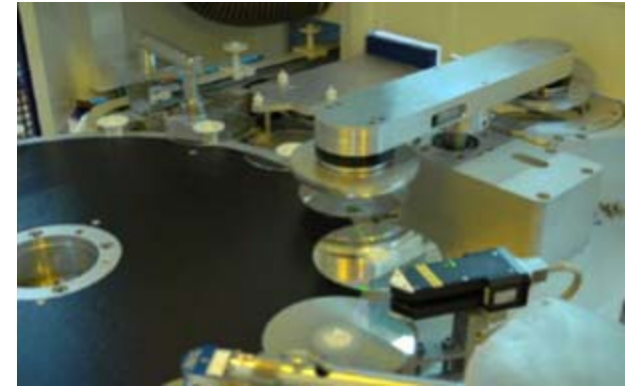




- Magazine with two unwind units of PC sheet for one day run without exchange prepared
- Highly accurate, precise and contact less transport of the PC sheet
- Punch and unload of the PC sheet by servo drive technology



- Sputtering of the reflective layer by the proven smart cathode technology
- Bonding of the 100um cover layer with a wet in wet spin bond technology
- Hard coating with a ultra thin layer by high speed spin process



BLU-LINE

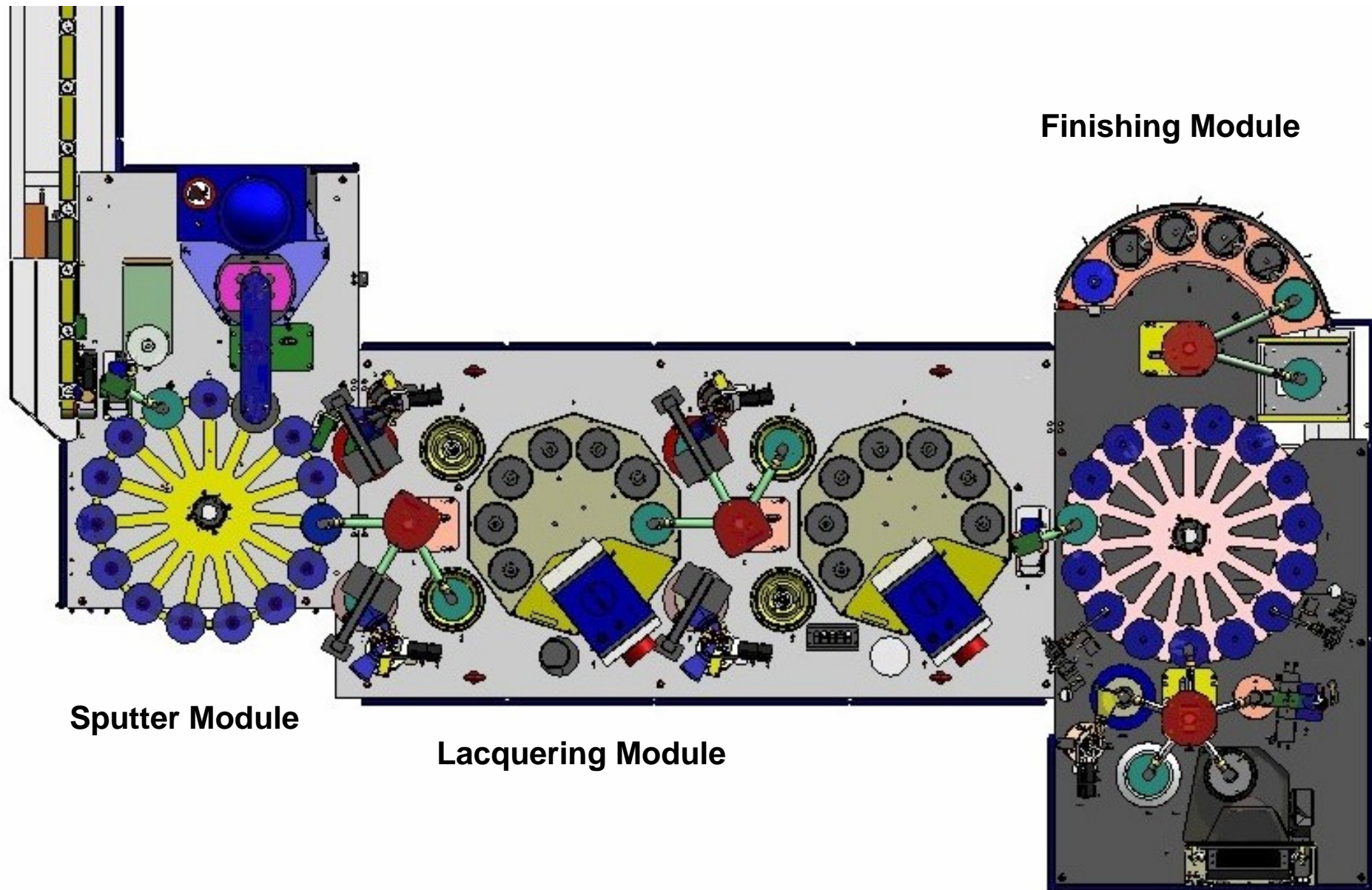
- 6. Liquid Resin Technology -

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October 10th, 2006

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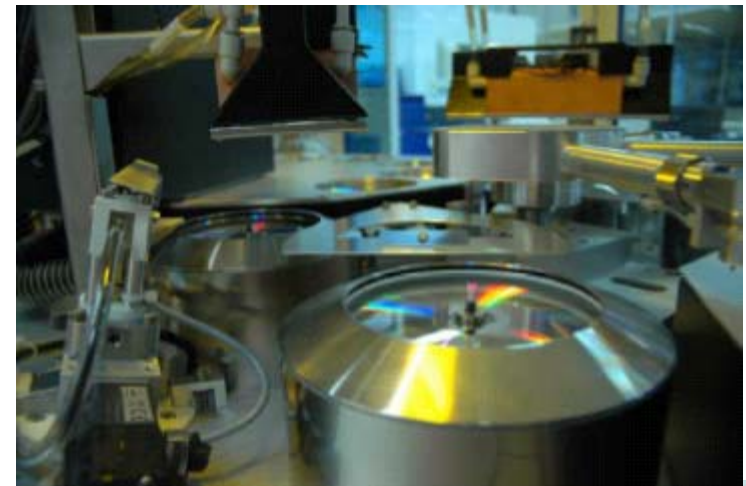


Sputter Module

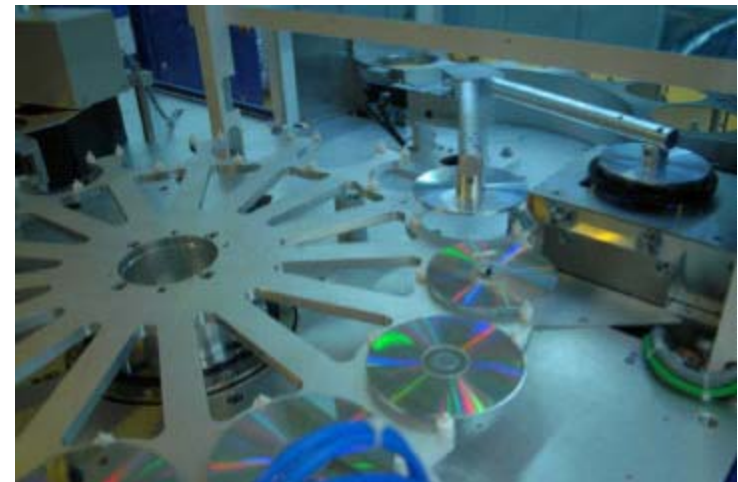
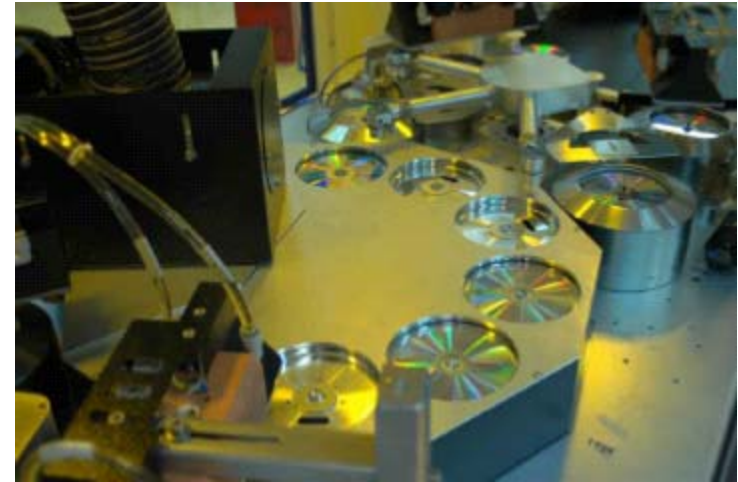
Lacquering Module

Finishing Module

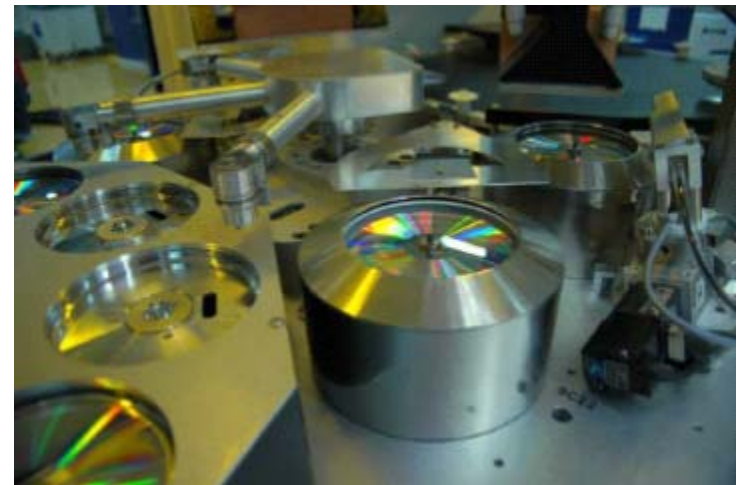
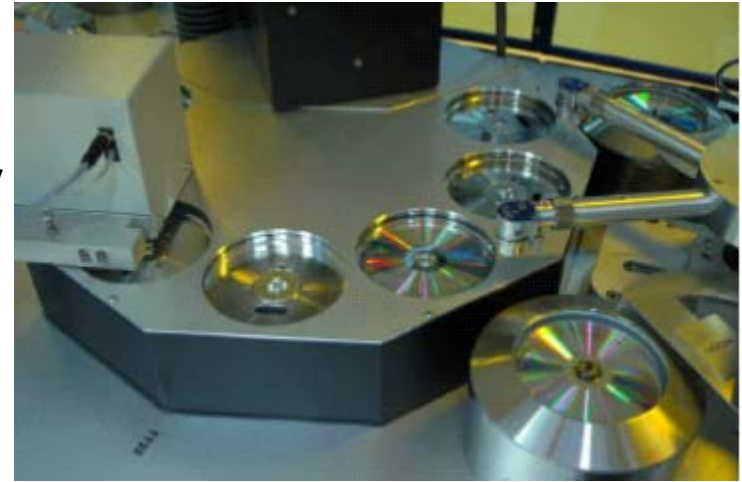
- Use of parallel track for highest throughput on smallest footprint
- IR-energy and masking technology for formation of steep increase of resin thickness at inner diameter



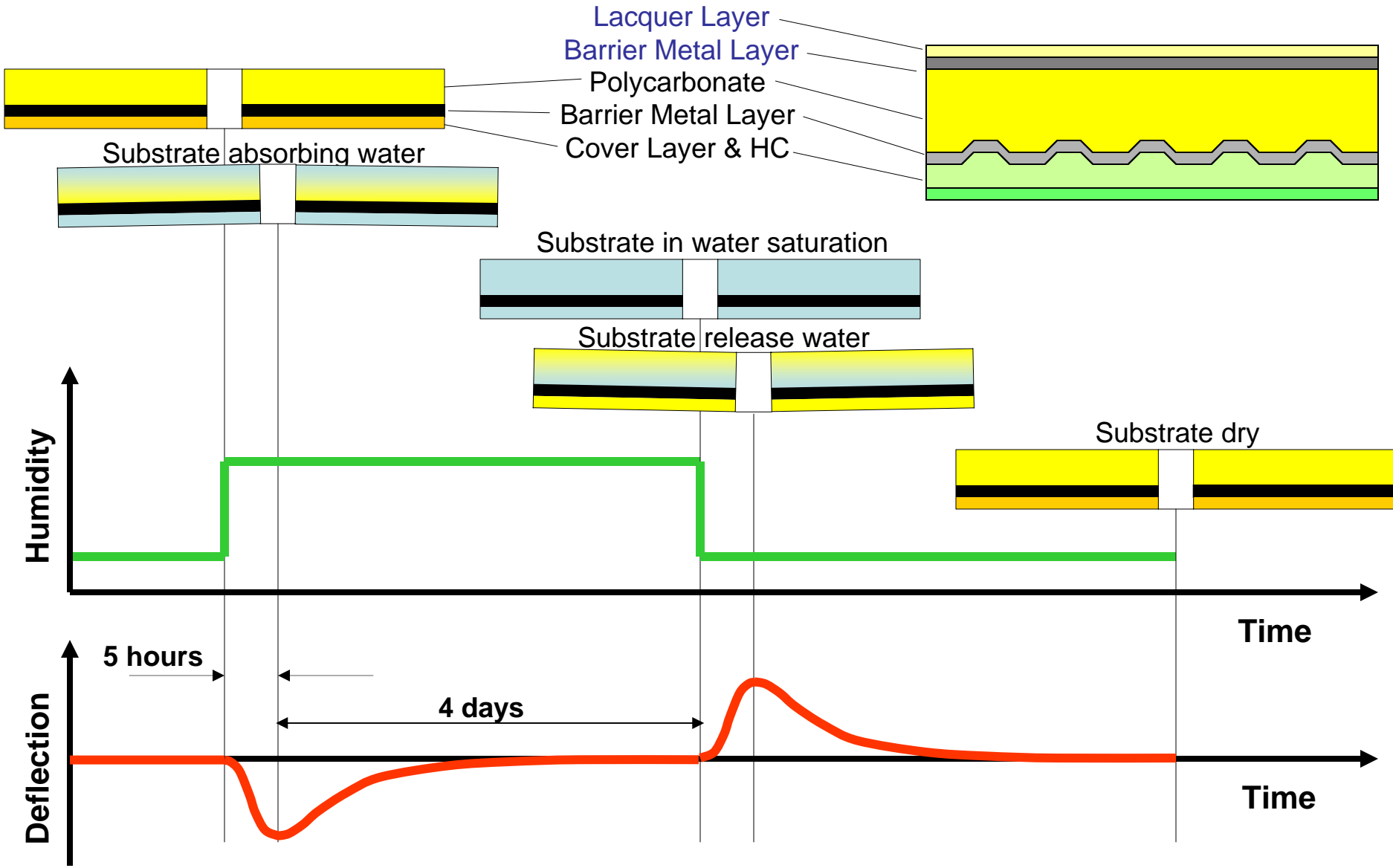
- Immediate and high efficient UV-curing by use of XENON lamp to avoid the formation of a resin bump at the outer edge of the disc
- Final inspection of the Blu-ray Disc by scanner technology of all major vendors possible



- Industrial accepted and well proven SINGULUS' closed loop control technology by use of a spectrometer
- Feed back of cover layer thickness and uniformity with the control of IR-energy and spin speed of the spin bowls



-7. Change of Humidity and Effect to BD Discs -



- Dual Layer Technology is important for the long term future of the BD Format to fulfill the need to accommodate the longest programs.

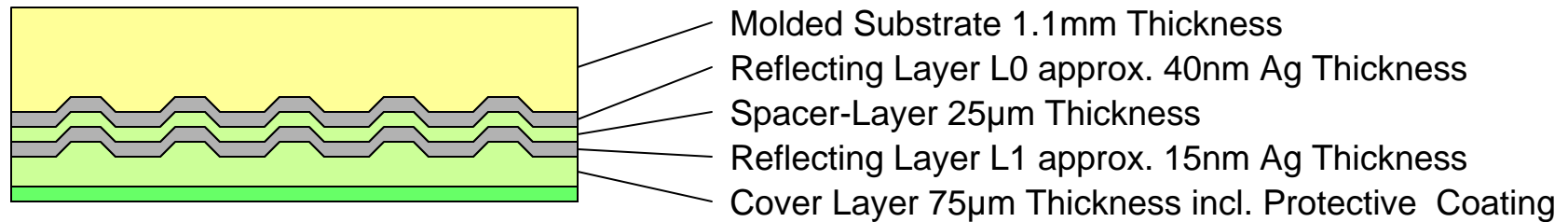
Design Parameters for a Dual Layer BD Process:

- A Dual-Layer Process Module shall be adaptable to a Single-Layer System:
 - A single layer machine shall be designed to accommodate an optional dual-layer module.
 - The dual-layer module shall match with the cycle time of the single-layer system.
 - The machine shall be easily switch able between single- and dual-layer products.
- The targeted Disc Manufacturing Cost of a Dual-Layer BD Disc shall be < 150% of a Single-Layer Product.

Key Factors determining Disc Manufacturing Cost are:

Process Stability, Line Output, Material Cost, Yield and Machine Cost.

Dual Layer BD-Disc Structure

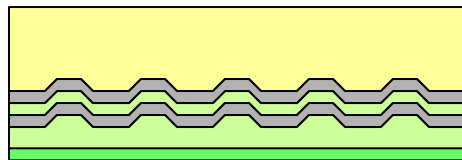
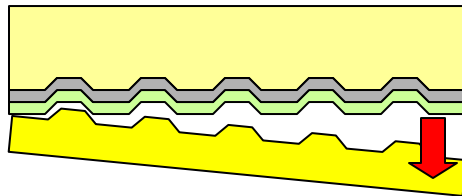
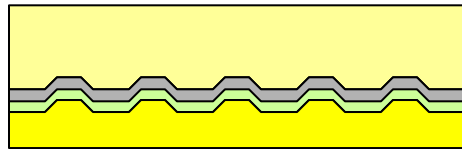
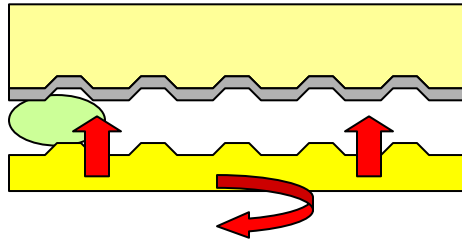


2 Methods are under Development:

- Plastic Stamper 2P Process (Polycarbonate, PMMA or Olefin as a Plastic Stamper Material)
- Imprinting Pit Structure into the 25 μ m Lacquered Spacer-Layer

- 8.3. Dual Layer Technology -

Plastic Stamper 2P Processes (Olefin Stamper):



**Molding of Substrate L0
Metallizing L0**

Molding of Substrate L1

Bonding L0 to L1

UV-Curing

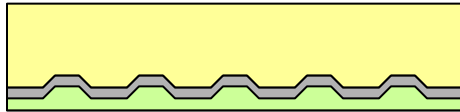
Separation of Plastic Stamper

Metallizing L1

Application of Cover Layer & Hard Coat

- 8.4. Dual Layer Technology -

Imprinting Processes (Metal Stamper):



Molding of Substrate L0

Metallizing L0

Lacquering L0

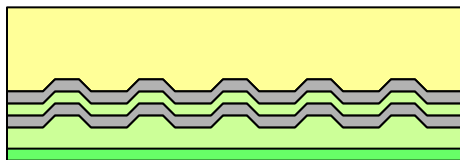
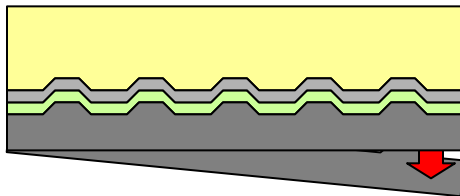
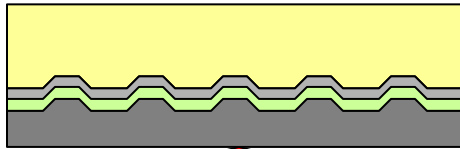
UV-Curing

Imprinting of Pit Structure from Metal Stamper

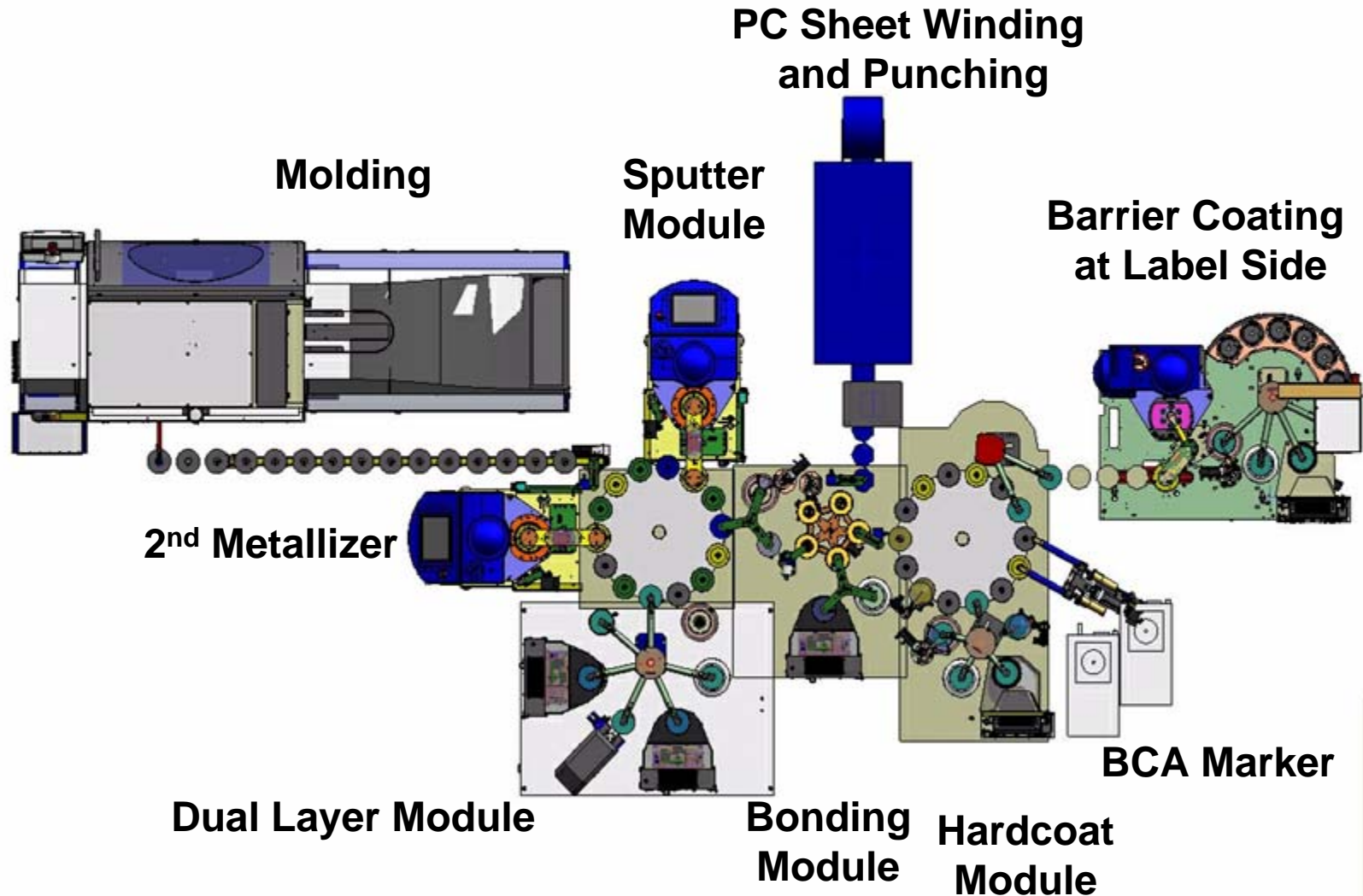
Separation of Metal Stamper

Metallizing L1

Application of Cover Layer & Hard Coat



- 9. BLU-LINE Options -



SINGULUS is ready for the Blu-ray Disc!

- **Very strong R&D, Design, Production and World Wide Service**
- **New machine concept is required for cover layer technology**
- **Known components like molding, metalizing and lacquering can be used**
- **Inspection systems from all major vendors are available**
- **Target for end of 2006: Yield >80% / Cycle time 4.0s**
- **Long term target: Yield 95% / Cycle time 3.0s**

- October 2005: Delivery of the first single layer systems to the market.
(Film and spin coat technology)
- June 2006: First BD-title market release
- Winter 2006: Dual layer module ready for upgrade of a single layer machine

3rd Generation:

- Multi layer BD up to 8 layers announced by Sony beyond 100 GB storage capacity

4th Generation?:

- Near field technology beyond 100 GB storage capacity single-layer

5th Generation?:

- Hologram technology

THANK YOU !!!

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