SINGULUS TECHNOLOGIES provides Optical Disc production systems with highest reliability.
SINGULUS TECHNOLOGIES INNOVATIONS

Technologic innovations change our lives. Smart phones, tablets, the cloud, industry 4.0, TV pictures in ultra high definition 4K quality as well as solar cells with an efficiency level of more than 20% are just a few examples for this.

SINGULUS TECHNOLOGIES develops innovative technologies for efficient production processes, which only make use of resources conservatively. New production technology combined with sustainable processes and the use of new materials can decouple the use of resources from economic growth in the long-term. SINGULUS innovative power and competitiveness are strengthened by these new technologic developments.

On the one hand, engineers, physicists and chemists at SINGULUS are initiators of new solutions and on the other hand, partners for institutes, research collaborations and R&D departments of large international corporations. The main focus is on industrial and applied research and development.

With the Optical Disc segment SINGULUS is the market leader for CD, DVD and Blu-ray Disc production equipment. As the only engineering company worldwide SINGULUS today already provides the machine technology for three-layer Blu-ray Discs with a storage volume of about 100 GB. Only Blu-ray Discs with these capacities will enable movie experiences in the new ultra high definition format 4K in "movie quality" in the future.

In the Solar division SINGULUS is a recognized supplier for new machines concepts and production processes for crystalline and thin-film solar cells, which increase the efficiency of solar cells and reduce their production costs. SINGULUS TECHNOLOGIES establishes itself as a development partner and machine supplier for technologies enabling a sustainable energy provision on the basis of renewable energies.

In the Semiconductor segment SINGULUS focuses its activities on the vacuum coating of wafers with ultra thin layers for the production of MRAM memory, thin-film write/read heads and other semiconductor applications.
BLULINE II
Enabling Fascination 3D
The success of 3D in the cinemas is encouraging, the Hollywood Studios are increasing the production of 3D movies, broadcasters are launching 3D channels, the consumer electronics industry is readying a whole range of 3D TVs and Blu-ray players. SINGULUS is supporting all that with the right replication equipment for the 3D Blu-ray Discs!

Hollywood Studios want to take advantage of the enormous storage capacity of a BD50 disc in order to deliver an unprecedented video and audio experience in Hi-def quality to the home consumer. For this reason, the availability of 50 GB Dual Layer Blu-ray Discs is a clear must for these formats.

The Blu-ray format has definitively established itself as the new standard in the market. High-definition television, HDTV (Full HD and 3D), combined with the Blu-ray video format, is the new technology of the media sector. The market introduction of the 50 GB Dual Layer Blu-ray Disc was a show-stopper for the entertainment industry. The high storage capacity of the format enables optimum audio and video High-Definition quality and also offers the ability to store bonus material such as additional trailers, interviews with directors and stars as well as BD-Java-based applications, enabling viewers to enjoy an interactive movie experience never possible before. The Blu-ray Disc will initially be the only method of delivering Full HD (1080p) 3D content to the home.

SINGULUS’ experience in the field of Blu-ray goes back to its early, exclusive partnership with the format developer Sony in 2005. SINGULUS has already a large number of production lines at over 30 replicators around the globe.

The SINGULUS Blu-ray Disc production system BLULINE II is designed for the economical production of Blu-ray Discs (BD ROM Single Layer and Dual Layer (BD ROM SL/DL), according to the specifications issued by the BDA.

All production steps from molding, cooling, metallizing, wet-embossing, lacquering and UV-curing to quality inspection are incorporated in the BLULINE II. Its functionality, speed and design will again set a new benchmark for the industry. The BLULINE II operates with one molding machine and comprises all the advanced features required for production of high end Dual Layer Blu-ray Discs.

The most common technology for creating an additional information layer on a substrate surface is the wet-embossing process. The benefit of the wet-embossing process is that it provides a very fine pit geometry and therefore generates a flawless electrical signal.

The dual layer process requires an excellent uniformity of the space layer between the two information layers (approx. 25±1 micron). This space layer is created by our field proven spin coating process and uses resin heating and curing to achieve the required uniformity. Finally the BD50 disc requires a precise 75 micron cover layer.
The following features characterize the BLULINE II concept:

- Dedicated to production of BD ROM SL/DL
- Cycle time BD SL < 4.0 s / BD DL < 4.5 s
- Highly integrated design
- All production steps included
- Thickness Measurement Device (TMD) for metallized layers with close loop control for the cathode
- Spectrometer for spacer-layer and cover-layer measuring with close loop control for spin process
- High productivity, high uptime
- Clear structured disc flow
- Automated handling of BD through all production steps
- Minimum space required
Sputter Station for Layer 0 and Layer 1 Metallization

For metallization of the molded Blu-ray Discs substrates with Layer 0 full-reflective material, one high sputter rate SINGULUS V module with the patented SMART Cathode® is used. Silver Alloy is sputtered with a layer thickness of approx. 35 nm. For the second metallization of the wet-embossed disc with Layer 1 semi-reflective material, the same sputter station is used. A second sputter module is used for sputtering the label side of the disc with a moisture barrier.

Dual Layer Cover-Layer Unit

Lacquering for the cover layer takes place on a double track module for high throughput. Each track consists of one lacquer dispense system, two spin bowls and one IR lamp. One pulsed UV lamp is alternating used for both tracks. By using the second spin bowl, a mask and the influence of heat from the IR lamp, a homogeneous thickness of cover layer is achieved. The combination of the UV station and an additional spin bowl creates a uniform shape and outer edge on the disc.

Wet-Embossing Station

The Layer 1 wet-embossing station is the key unit of the dual-layer application. This unit is built with a 4-position turntable and one embossing head. The embossing head is designed for the Layer 1 wet-embossing process with a Nickel stamper in the uncured pit-transfer resin. The Layer 0 disc is loaded onto a quartz glass for embossing and is centered with a center pin. The Layer 1 stamper is mounted onto the top side of the embossing head and is supported by vacuum and a mechanical stamper holder.
Main Components

1 **Injection Molding**
SINGULUS has qualified the MOLDPRO/2 All-Electric molding machine for Blu-ray Disc production. Other qualified molding machines can be integrated on request.

2 **Cooling Conveyor**
A linear cooling conveyor transports the discs in a horizontal position through a separate conveyor belt to the downstream. This additional cooling of the substrates during transportation provides a uniform temperature distribution over the disc surface.

3 **Layer 0 Metallization**
A high-rate SINGULUS V sputter module with the patented SMART Cathode® is used for the metallization of the molded Blu-ray Disc substrates with Layer 0 full-reflective material. Silver Alloy is sputtered with a layer thickness of approx. 35 nm.

4 **Base Resin**
Lacquering takes place on a double track module for high throughput. Both tracks are connected to one lacquer dispense system, two spin bowls and one IR lamp. One Xenon pulsed UV lamp is used for each track. The combination of a spin bowl and the UV station creates a uniform shape and outer edge on the disc.

5 **Pit-Transfer-Resin**
This unit consists of one lacquer dispense systems and two spin bowls. The discs are transported by one handling system. Once the metallized and resin-coated disc reaches the first position, a highly accurate circular ring of lacquering agent is applied onto the disc with 2 µm pit-transfer-resin.

6 **Pre Curing**
A one-position turntable to pre-cure the center of the lacquered Blu-ray Discs is positioned just prior the wet-embossing station.

7 **Wet-Embossing Station**
The Layer 1 wet-embossing station is the key unit of the dual-layer application. This unit is built with a 4-position turntable and one embossing head. The embossing head is designed for the Layer 1 wet-embossing process with a Nickel stamper in the uncured pit-transfer resin. The Layer 0 disc is loaded onto a quartz glass for embossing and is centered with a center pin. The Layer 1 stamper is mounted onto the top side of the embossing head and is supported by vacuum and a mechanical stamper holder.

8 **Layer 1 Metallization**
For the second metallization of the wet-embossed disc with Layer 1 semi-reflective material, the same sputter station is used as for Layer 0. Silver Alloy is sputtered with a thickness of approx. 30 nm.

9 **Cover Layer**
Lacquering the cover layer takes place on a double track module for high throughput. After UV curing, the disc is positioned directly under a spectrometer to measure the cover layer thickness and uniformity. With these results, a closed loop cover layer control is generated to ensure constant thickness and uniformity.

10 **Hard Coating**
The hard coat is performed with a spin process, ensuring a very thin and uniform distribution of the hard coat material. Afterwards, the disc will be UV-cured and positioned on the conveyor. A flip-over handling arm brings the print side of the disc facing up.

11 **Barrier Layer**
A SINGULUS V module is used for sputtering the label side of the disc with a moisture barrier. SiN is sputtered with a layer thickness of approx. 10 nm.

12 **Final Inspection**
The unique layer thickness measuring system controls the layer thickness and layer uniformity of each metallized substrate automatically.
Main Features

**Format**
- BD ROM
- Single Layer & Dual Layer

**Cycle time**
- DL < 4.5 s
- SL < 4.0 s

**Space layer**
- 25 μm

**Cover layer BD DL**
- 75 μm

**Cover layer BD SL**
- 100 μm

Metallization

**Fully reflective layer**
- Ag+ (approx. 35 nm)

**Semi reflective layer**
- Ag+ (approx. 30 nm)

**Barrier layer**
- SiN (approx. 10 nm)

Available Options

Adaption of BCA module

Dimensions BLULINE II
(with MOLDPRO/2 Injection Molding Machine)

**Length**
- 4500 mm

**Width**
- 3700 mm

**Height**
- 2080 mm
SPACELINE II
The best gets better again!
With a market share of more than 65%, SINGULUS TECHNOLOGIES is offering its latest version of the replication line SPACELINE II: this system is capable of producing all Single and Dual Layer DVD (9, 5, 10) formats.

Based on the experience of 1400 systems in the market, the SPACELINE II offers a process cycle time faster than 2.3 sec.

The SPACELINE II achieves the most cost-efficient disc production and highest product quality and yield available in the market, making it the new industry benchmark for DVD.

The SPACELINE II is delivered with two MOLDPRO/2 molding machines.

With the MOLDPRO/2 all-electric molding machine the SPACELINE II provides the smallest footprint worldwide. Other qualified molding machines may be integrated on request.

The SPACELINE II, with many patented original parts (SMART CATHODE®, TMD, Spin Cooler, etc.), ensures a high daily production rate for DVD.

With its worldwide sales and service network, SINGULUS TECHNOLOGIES is able to provide exceptional support together with technological synergies to benefit our customers.
Concept

Dedicated to produce DVD 5, DVD 9 and DVD 10

- Production cycle times
  - 2.30 seconds for DVD 5 and DVD 9
  - 2.50 seconds for DVD 10

- Confirms to either CE or UL industrial standards

- Modular, highly integrated design incl. all production steps from molding, spin-cooling, metallizing, bonding, UV curing to quality inspection

- Minimum space required
- Transmission Measurement Device (TMD) for closed loop control of both metallized disc halves
- High productivity and high uptime
- Clear structured disc flow, avoiding mismatch between discs halves
- Automated handling of DVD through all production steps

- Excellent maintenance and service accessibility
- Highly reliable
- DVD handling by mechanical 3-finger grippers via center hole of disc
- Transportable to the production site with fork lift truck
Main Components

1 Injection Molding
The MOLDPRO/2 all-electric molding machine is designed for the economic production of CDs and DVDs. Its direct drive concept guarantees highest precision and repeatability to ensure disc quality according to the specifications issued by the Philips Intellectual Property & Standards Organization. The MOLDPRO/2 molding machine is equipped with its own computer control unit and is fully integrated into SPACELINE II and interfaced with PLC.

Other qualified DVD molding machines can also be integrated upon request.

2 Spin Cooler Unit
Provides fast and homogenous temperature reduction on the discs. Allows handling and managing of the disc halves without deviation and birefringence impact.

3 Input Conveyor
An adjustable clean airflow device results in best pre-process conditions for every single substrate.

4 SINGULUS V Metallizer with TMD Sputter Layer Measurement
With more than 6000 units, the latest Singulus metallizer has proven its reliability and efficiency with our major customers. Both metalizers in the SPACELINE II are equipped with SMART CATHODES®, allowing the use of a large range of sputter materials. By implementing a closed-loop system between the metalizer and the Thickness Measurement Device (TMD), SINGULUS has exceeded requirements for layer uniformity while also extending target lifetime as compared to other systems on the market.

5 Bonding Resin Dosing Unit
Separate units for degassing, dosing and recycling are combined with an accurate dosing pump in one small, lightweight device. Accommodates a large range of recommended bonding resins.

6 Bonding Station
VI2-Bond is installed to prevent air inclusions in the bonded disc at faster bonding times.

7 Spinning Station
Dual spin bowls in series for high speed DVD production.

8 UV Curing Station
- Adjustable power and curing time
- Low power consumption
- Simultaneous top, bottom and side curing
- Excellent edge curing
- Motor driven tilt compensation

9 Final Cooling Conveyor
Eight positions for completed discs, including a blow-off station with exhaust system.

10 Scanner
Ready for the latest version of quality inspection units.
**Product**
- **DVD:** DVD 5, DVD 9, DVD 10, DVD[Plus]©
- **Diameter:** 120 mm / 80 mm

**Metallization**
- **Fully reflective layer:** Al (approx. 40 nm)
- **Semi reflective layer:** Ag+ (approx. 9 nm)
- **Au** (approx. 15 nm)
- **Si** (approx. 20 nm)

**Target Lifetime**
- **Aluminium:** up to 130,000 shots
- **Silicon:** up to 200,000 shots
- **Silver Alloy:** up to 550,000 shots (depending on target manufacturer)

**Performance DVD**
- **Cycle Time:** 2.30 s (Ag+) 2.50 s (Si/DVD 10)
- **Output:** 33,000 29,500 (Calculated without stamper change)

**Recommended Molding Equipment**
- **MOLDPRO/2:** MP 60
The SKYLINE II Duplex Replication Line from SINGULUS TECHNOLOGIES covers the production of CD and DVD 5. With the installation of over 2000 systems to date, the SKYLINE is the industry benchmark.

The upgraded SKYLINE II combines CD and DVD 5. A built-in pushbutton function to switch from CD to DVD 5 and back is standard. This machine achieves the most cost-efficient disc production and highest product quality and yield available in the market.

The SKYLINE II is equipped with one molding machine, one SINGULUS V metallizer, one spin-off bowl (two for DUPLEX), a UV-curing device and an inspection system for quality assurance of the finished discs.

The SINGULUS V is our latest optical disc metallizer and has been part of our product line for several years. The high performance of this metallizer significantly contributes to the increased reliability, maximum uptime and easy maintenance of the SKYLINE II.

With many patented original parts, the SKYLINE II ensures a high daily production of CD & DVD. With the worldwide sales and service network of SINGULUS TECHNOLOGIES, we are able to offer exceptional support and technological synergies to benefit our customers.
Main Characteristics

- Able to produce CD-Audio / CD-Video, CD-ROM
- Available upgrade for DVD 5
- Modular, highly integrated design
- All production steps from molding, metallizing, bonding, UV-curing to final quality inspection included
- Minimum space required
- Integration of the established SINGULUS V metallizer
- Production cycle time including molding ≤ 3.3 seconds for CD and ≤ 6.0 seconds for DVD 5 (depending on molding equipment)
- Discs downstream ≤ 2.5 seconds for CD and ≤ 5.6 seconds for DVD 5
- Entire machine including electric rack mounted on a base frame
- Clear structured disc flow with automated handling of CDs (DVDs) through all production steps
- Excellent maintenance and service accessibility
Main Components

1 Injection Molding
The MOLDPRO/2 all-electric molding machine is designed for the economic production of CDs and DVDs. Its direct drive concept guarantees highest precision and repeatability to ensure disc quality according to the specifications issued by the Philips Intellectual Property & Standards Organization. The MOLDPRO/2 molding machine is equipped with its own computer control unit and is fully integrated into SKYLINE II and interfaced with PLC.

2 Cooling Conveyor
The high take-out temperatures generated by fast cycling molding machines make it necessary to cool down the discs before further processing. Therefore, SKYLINE II has an integrated cooling conveyor with 13 positions between each delivery point, from the molding machine take-out robot to the sputter module transfer position.

3 Sputter Station
One important feature of the SKYLINE II is the integration of the SINGULUS V high rate sputter equipment. The high performance of this metallizer significantly contributes to the increased reliability, high uptime and quick repair times of the SKYLINE II. The system is equipped with one energy-saving, high performance FOCUS Cathode® achieving the specified layer characteristics for the metallization of CD and DVD 5 layers.

4 Spin-Off Units
The first spin-off bowl is used to rotate the disc while dispensing the lacquer or bonding resin. For CD production, the protective lacquer is distributed with high uniformity by means of spin-off. In DVD 5 mode, the bonding resin is dispensed onto the bottom disc half, then the top side disc is smoothly placed onto the resin. In the SKYLINE II DUPLEX, a second spin-off bowl is integrated next to the first one. This second bowl, with its assortment of spinning speeds, is used to ensure high uniformity of the bonding agent between the disc halves.

5 Bonding (DUPLEX only)
The bonding unit consists of a dosing system with a degassing unit, two spin-off bowls and an I-BOND® system, guaranteeing the prevention of bubble generation during the bonding process.

6 UV-Curing
The UV-curing station has a two-position turntable. The rotation of the disc in front of the UV-bulb guarantees a constant and uniform curing of the CD or DVD 5 as well as excellent curing results for the DVD 5 disc edge.

7 Final Inspection
The SKYLINE II is equipped with a high quality final inspection system for CD; the SKYLINE II DUPLEX has a different scanner for the inspection of DVD5.

8 Control Unit
The SKYLINE II is controlled through one Siemens S7 and one Mitsubishi PLC. With a 15” touch screen, the visualization concept helps the operators to become rapidly accustomed to the operation of the whole line.
**SKYLINE II**

| Product | CD-Audio, CD-ROM  
| Options: CD-Card, DVD 5 |
| - Diameter: | 120 mm (80 mm media on request) |
| - Thickness: | 1.2 mm +/- 0.1 |
| - Material: | Polycarbonate (PC) |
| - Metallization: | Aluminum |
| - Resin: | qualified protective lacquers or bonding agents for UV-curing |

| Product Cycle Time | ≤ 3.3 s CD  
| ≤ 6.0 s DVD 5  
| (depending on molding equipment) |
| - Dry cycle time CD: | ≤ 2.5 s (one spin bowl) |
| - Dry cycle time DVD 5: | ≤ 5.6 s (two spin bowls) |

| Target Lifetime | up to 200,000 at 55 nm thickness  
| up to 250,000 at 40 nm thickness |
STREAMLINE III
High Performance Replication System for DVD R
The STREAMLINE III is a replication system dedicated to the economical mass production of high performance DVD R.

The STREAMLINE III replication line is designed for a dry cycle time of the downstream equipment of less than 2.5 s. A production cycle time of better than 2.8 s can be achieved for 4.7 GB media depending on the dye process and the cycle time of the injection molding machines. Reproducible and stable in operation, the fast STREAMLINE III is the result of our R&D activities in multiple interacting process areas, from mastering and molding and dye technology to metallization and bonding.

The STREAMLINE III is equipped with the SPACELINE II finishing module. The new system combines the advantages of an economically designed system with the proven SPACELINE DVD replication line based on a market base of over 1400 systems. The final processing of recordable DVDs is performed using a SMART CATHODE® sputtering unit and the reliable SPACELINE II bonding module.

SINGULUS TECHNOLOGIES is well prepared to provide all process know-how necessary to start up production of recordable DVD media.

Optional DVD 5 production
For manufacturing DVD 5 at low cycle times until the end of the target lifetime, a 10 kW power supply for SP1 is installed instead of a 8 kW power supply.

- Production cycle time DVD 5 (without metallized top disc): 2.50 seconds (Al layer ≤ 40 nm).

Optional CD production
This option enables the STREAMLINE III to manufacture Compact Disc formats (CD-Audio, CD-ROM) while using only one of two injection molding machines. Therefore some parts at the spin-off and sputter units have to be exchanged.

If not ordered separately, neither the mold for CD manufacturing nor the devices to be exchanged are part of the scope of delivery.

- Production cycle time CD: 3.40 seconds
- Target lifetime for Aluminum: Up to 130,000 at 40 nm thickness
Dye Coating: Precise, controlled, perfect.
Uniform dye application, low material consumption and high production speeds – STREAMLINE III sets new standards in dye coating.

The system operates with six dye coating cups, driven by AC servomotors.

Heating. For active discs.
To remove residual solvent out of the condensed and air-dried dye film, the inspected dye coated substrates are fed into specially designed drying unit.

Metallizing: Fast, efficient, consistent.
The Streamline III uses a powerful metallizer that optimizes the process. For metallization of the molded (DVDR respectively DVD/CD substrates) with reflective material, one SINGULUS V high rate sputter module with patented SMART CATHODES® is used.

Each sputter module (SP1) is driven by a separate 10 kW (400-1000V) power supply.
Main Process Steps

1 Injection Molding
Two equal and qualified DVD R injection molding machines including DVD R molds, take-out robots and temperature control units are used.

2 Cooling System
All substrates are brought to ambient process temperature and humidity in a cooling conveyor for further processing in the dye coating unit.

3 Dye Coating Unit
The dye coating unit of the STREAMLINE III can be equipped with up to 6 process stations for the application of a layer of organic recording material onto each grooved polycarbonate substrate.

4 Take-out
There is one three-arm transfer handling system to transport the substrates from the conveyor to the dye inspection unit, to the sample take-out position and laser marker unit, and back to the conveyor.

5 Drying Unit
To remove residual solvent from the condensed and air-dried dye film, the inspected dye coated substrates are fed into the drying unit.

6 Sputtering Unit
For the deposition of a thin reflecting film (metal layer) onto the dye coated substrates, the high rate sputter unit SINGULUS V is used.

7 Substrate Conditioning
The cooling unit, with air supplied from an independent climate unit, acts as a conditioning station to ensure the layer 0 substrates are thermally conditioned for the dye coating process.

8 Edge Cleaning Stations
Removes residual dye on the edge of the dye coated and metallized layer 0 substrates.

9 Transfer Conveyor
One transfer conveyor transports the blank layer 1 substrates to the bonding unit.

10 Bonding Unit
Bonding takes place on a four-position turntable, where bonding material is dispensed onto the metallized and edge-cleaned information side substrates.

11 UV-Curing Station
In the UV-curing station, the discs are exposed to ultraviolet radiation to cure the bonding material by means of a radical polymerization reaction.

12 Final Cooling Conveyor
An eight-position conveyor is applied to cool each DVD R after UV-curing to ensure that the discs are in thermal equilibrium when they reach the following final quality control system.

13 Inline Quality Inspection System
A two-step inline quality inspection system is integrated in the STREAMLINE III. This concept includes the intermediate inspection of dye coated layer 0 substrates and the final inspection of the finished DVD R.
**Product**

Digital Versatile Disc Recordable, Compact Disc (CD-Audio / CD-ROM / DVD 5)

- **Diameter:** 120 mm
- **Thickness:** Depending on disc format
- **Material:** Polycarbonate (PC)
- **Reflective Layer:** Aluminum
- **Semi-Reflective Layer:** Silver-Ag, gold and others on request
- **Bonding Agent:** Qualified for UV-curing

- **Total Cycle Time:**
  - DVD R: ≤ 2.80 seconds
  - DVD 5 with clear top disc: 2.50 s
  - CD: 3.40 s

**Target Lifetime of SMART® Targets**

- Silver Ag for DVD R: up to 90,000 at 100 nm thickness
- Aluminum for DVD 5: up to 130,000 at 40 nm thickness

**STREAMLINE III**
SINGULUS TECHNOLOGIES, the global market leader in production equipment for optical discs, presents the CRYSTALLINE: The in-line solution for mastering of pre-recorded Blu-ray Disc (BD25, BD50, 3D BD).

Based on the “Glass substrates in – Finished Masters out” principle, the system incorporates the SINGULUS’ proprietary PTM process and custom-designed Laser Beam Recorder. The CRYSTALLINE is designed for maximum unattended operation, and offers the lowest Cost of Ownership, ensuring maximum return on investment. By offering all specific technologies, from BD mastering to BD replication, SINGULUS is in the unique position to deliver complete and fully optimized solutions for BD manufacturing.

The CRYSTALLINE system incorporates a wet station for cleaning, developing and DOM measurements, a “single chamber – three target” sputtering unit for application of the PTM recording and nickel layers and an innovative Laser Beam Recorder performing the recording process. The use of the Phase Transition Mastering (PTM) process, combined with advanced waveshaping technologies enables the use of the proven 405 nm Solid State Laser on the new LBR. The signal encoder incorporates advanced waveshaping technology feeding the laser. The central substrate “warehouse”, combined with innovative, patented, scheduling algorithms ensures the shortest production cycle possible in the machine.

The experience gained in building mastering systems for first and second generation optical formats, combined with a newly designed Laser Beam Recorder and Sputtering Unit incorporating the SINGULUS Smart Cathode® technology has resulted in a reliable machine for in-line mastering of the Blu-ray Disc format.

With its worldwide sales and service network, SINGULUS TECHNOLOGIES is able to provide exceptional support together with technological synergies to benefit our customers.
Concept

The mastering process of the CRISTALLINE machine is based on the proprietary Phase Transition Mastering (PTM) technology. The PTM recording process enhanced with customized waveshaping allows the creation of the desired pit geometries after development and the subsequent galvanic step. Waveshaping is an integral part of the system and is strongly linked to the 405 nm solid state laser. The encoder is used to encode the data for Blu-ray Disc, with the required protections such as AACS and ROMMark.

It is also used to generate the signal for graphic bands on the disc. A novel and intuitive user interface gives immediate status overview on the machine also accessible remotely, and the orders being processed. Data generated by each station, which is linked to the order by DiscTag, can be viewed at the machine in the form of reports, or be made available for further analysis as exported XML files.

XML is also the structuring language that describes each individual station and recipes, covering all process steps, used for creating the master.
The Stations and Logistics

1 The Laser Beam Recorder has been designed to meet the stringent requirements posed by the BD format. Modern modelling technologies and innovative design have resulted in an exceptionally stable LBR. All movements in the LBR support mastering at high speeds (up to 3R) when such encoders become available. Especially the newly developed Learning Feed Forward Control (LFFC) makes this possible.

2 The Sputtering Unit was specially designed to perform two tasks; preparing the substrate for recording and finishing the substrate after development, so it can subsequently be used in galvanics.

The first step consists of sputtering a base silicon layer, followed by the PTM layer. The layer thickness variation is less than 2 nm over the program area of the disc.

3 The wet station combines the functions of cleaning, development and reflection/diffraction (DOM) measurement. After recording of the disc, the wet station develops the substrate based on order criterion.

4 The Warehouse, having 100 storage locations for substrates, plays a vital role in having the CRAYSTALLINE achieve its maximum throughput. The warehouse also makes it possible to run unattended mastering for 24 hours or more.

5 The Handler, selected for reliability and speed, can reach all process locations in a short time. Handling time between process steps is no longer a delaying factor in the throughput of the machine.

6 The Intake accepts cartridges holding 20 substrates.

7 The Unload delivers the finished masters each in a dedicated box. It also offers the possibility to load a single substrate for processing or measuring in the CRAYSTALLINE.

8 The substrate used in the machine has an industry-wide accepted diameter of 180 mm. The polished glass disc, combined with a hub, guarantees optimum quality while maintaining easy handling and fixation on the stations throughout the machine.

Monitoring of the job progress and machine status is possible by means of the VNC interface that also offers remote control of the Mastering System. This function can be accessed by the customer’s personnel at the factory or remote location. It also facilitates SINGULUS TECHNOLOGIES to give “Remote Support On Site”.
Mastering Formats:
Pre-recorded Blu-ray Disc
All mastering data to be delivered through Gigabit Ethernet link. Support for AACS and BD ROMMark

Production Capacity:
- Blu-ray Disc: 14 masters per 24 hours at 1R
  20 masters per 24 hours at 1.5R

General Details:
- Width: 1.7 m
- Length: 2.5 m
- Height: 2.3 m
- Weight: 2.100 kg
- Room Conditions: Temperature 18 - 24 °C
  Humidity 40 - 70 % RH

Laser Beam Recorder:
- Type of Laser:
  Directly modulated twin input –
  quad level solid state laser diode (405 nm)
- Expected Laser Life Time:
  > 10,000 hours
- Focus:
  Using recording beam. Learning Feed Forward Control (LFFC)
- Translation:
  Linear motor attached at centre of gravity
- Rotation:
  Brushless DC motor, with embedded tacho
- Substrate:
  Ø 180 mm glass (1.6 mm thick) with hub delivered in cassette for 20 substrates

Utility Requirements:
- Electrical Supply: 230/400 V 50/60 Hz
- Power Consumption: 10 kVA
- Di Water: 2.6 l / master
- Argon Gas: 80 Nm³/min ( = 80 sccm)
- Compressed Air: 250 Nl/min at > 8 bar

Sputtering Target Lifetimes:
- Si: > 10,000 shots
- PTM: > 10,000 shots
- Ni: > 5,000 shots

Technical alterations reserved
DMS Evolution
Cost-Effective High-Speed Mastering
DMS Evolution

Cost-effective solution for any production environment

The DMS Evolution is the latest generation of in-line mastering systems based on the DMS concept. In a time span of just over 15 years since its introduction, a number of close to 100 DMS systems have been installed worldwide. Today, the DMS Evolution is recognized as the most popular mastering system in the market with installations in 38 countries.

The DMS Evolution is the ideal solution for mastering facilities where high volume pre-recorded CD and DVD master production is required. The DMS Evolution is characterized by the simplicity of design and ease of use and maintenance. This provides a reliable platform for all production environments. At the time the DMS platform was presented, it showed a revolutionary concept in mastering technology, and meantime these ideas have enjoyed more and more supporters. The DMS concept was the first in the market offering the possibility to integrate a second Laser Beam Recorder (LBR) in the same frame. The unique double Laser Beam Recorder capability is central to the DMS concept and allows the system to be easily and quickly expanded for increased production capacity. Integration with Network Mastering further enhances the flexibility and productivity of the system.

Typical of its workhorse capabilities, the DMS Evolution recording speeds have been increased to 4R for DVD (from 2R) and to 10x for CD (from 6x). With this increase in speed, a DMS Evolution equipped with 2 LBRs can achieve an output of up to 140 DVD masters per day. This results in the lowest cost per master in the industry.

A first order sensor and feedback loop fine-tune the accuracy of the development process. This provides for an extremely high level of stability and reliability. The dedicated Air Handling Unit (AHU) not only ensures that the air flow inside the DMS Evolution is maintained at class 100 clean room conditions, but also controls the temperature and relative humidity of the air. This will allow the DMS to operate reliably in an environment where there is considerable variation in temperature and humidity.

The highly modular design of the system provides the flexibility required for the implementation of future technologies and options.
DMS Evolution

- Mastering Formats: Standardized pre-recorded CD and DVD formats. All CD at 10x real time and DVD at 4 reference recording speed.

- Media Input system:
  - Supported Media: Gigabit networking environment, (S)DLT tape drive, DVD-(R) input drive, CD-(R) input drive

- Optional:
  - Copy Protection: CSS encoding
    Several copy protection schemes available

- Laser Beam Recorder:
  - Type of Laser: Directly modulated solid state laser diode (405 nm)
  - Expected Laser Lifetime: > 9000 hours
  - Increase of Output: Base system can be equipped with 2 LBR systems to increase output

- Networking: Mastering Super Highway networking connection, Cytris downloading system, with two input drive of each (S)DLT tape/DVD-ROM and storage capacity

- General Details:
  - Width: 1750 mm
  - Length: 1750 mm
  - Height: 2200 mm
  - Footprint: 3 m²
  - Weight: 600 kg
  - Room Conditions: Temperature 18-24 ºC, Humidity 40-70 % RH

- Utility requirements:
  - Electrical Supply: 100-240 VAC, 50/60 Hz
  - Power Consumption: < 3 kW maximum
  - DI Water: < 3 l/h
  - Argon Gas: < 0.2 l/h
MOLDPRO/2
All-Electric Injection Molding Machine
With its latest generation of exclusively designed all-electric injection molding machine for optical storage media, SINGULUS TECHNOLOGIES AG has closed the loop of high efficient Blu-ray mass production.

The conjunction of CRYSTALLINE Mastering, MOLDPRO/2 Molding and BLULINE downstream ensures a superior replication chain; stable processes with the highest precision and repeatability at the shortest cycle times.

In molding, the high demands in optical disc production – best mechanical properties, especially with regards to substrate flatness and high replication rates of the tiny pits, the digital content out of a Blu-ray stamper – are fulfilled with the compact machine concept of MOLDPRO/2. This platform with meanwhile more than 350 installed injection molding machines worldwide for CD, DVD and BD manufacturing in continuous operation (24/7) is also capable for other applications like the field of medical engineering with its clean-room requirements or high precision injection molding of other thin-wall optical polymers.

With the low energy consumption, the short set-up time and software features like the “slow cycle mode” which helps saving raw material in case of an unforeseen production stop, MOLDPRO/2 constitutes an economic disc manufacturing system.
Main Components MOLDPRO/2

Injection Unit
Inside the hardened barrel, there is a 28 mm plasticizing screw with the non-return valve. Each part is surface-coated with TiN against wear and corrosion as well as for processing technical polymers (PC, PMMA) with best optical characteristics. The barrel is divided into six individually controlled heating zones with an accuracy of +/- 0.2 degrees. The special synchronization software ensures a careful and simultaneous heating of the single zones. The nozzle of the plasticizing unit is actively opened and closed by a pneumatic driven needle shut-off nozzle system for a smooth start-up, and together with the precise metering control a high melt homogeneity and very low shot weight variation are achieved. In production, the nozzle tip is in permanent contact with the sprue bush to minimize wear.

Mold
The mold is designed by SINGULUS. Due to the patented E-clamp concept no centering mechanism is needed between the two mold halves, which results in a low weight (one mold half is about 10 kg), an easy access and a fast maintenance. Most of the parts, like the BD mirror with its frosted surface and the “screen printing” option, are produced with a tolerance of three microns for best mechanical characteristics.

Temperature Control Unit (TCU)
The TCU is a closed DI water circuit added with a Biocide and an anti-corrosion agent independent on factory water. The primary circuit supplies cooling water out of a buffer tank to the high torque servo motors, all amplifiers, the mold mounting platen, the tie-bars and the feeding zone of the barrel. The second circuit is divided into four mold circuits. Each of these circuits can be precisely adjusted between 20 °C and 140 °C. All components are specially selected to ensure long lifetime, like magnetic coupled pumps and parts of either stainless steel or brass.

Take-Out Robot
The servo driven take-out robot has an integrated mechanical gripper and is connected with a high efficient vacuum pump for a fast and exact removal of disc and sprue. An optical sensor for the sprue detection and analog sensors for a precise disc vacuum monitoring are implemented to the system. The mechanical components and the drive concept of the take-out robot guarantee short cycle times due to fast disc take-out and short mold opening stroke. A long lifespan, mechanical robustness and easy teach functionality complete the take-out system.

Clamping Unit
The complete system, particularly the clamping unit, was designed by Finite Elements Analysis guaranteeing long durability and high stiffness. Very fast opening and closing speeds shorten the cycle times considerably. The direct drive system offers precise positioning and high replication rates as a result of the high acceleration movements. Due to the patented E-clamp system, the parallelism of the mold mounting plates can be influenced by motor offset adjustment via Human Machine Interface. This feature enables optimization of substrate thickness distribution caused by uneven stampers.

Human Machine Interface (HMI)
The 10 inch coloured LC touch screen enables easy access to the machine operation. The menu is clearly arranged and different languages can be selected. All important parameters can be monitored, either within one cycle to observe the process behaviour, or with the trend graph over 500 shots to judge about process stability. Every parameter change is saved in a log-file. Machine data transfer (e.g. recipe management) can be easily done with USB sticks.