BD technology

Masters of the universe: creating stampers for Blu-ray

The more things change, the more they stay the same: though a complicated process for the hi-definition Blu-ray Disc format, mastering follows the same basic principles as it did for DVD, Elizabeth Toppin discovers

Inside the LBR: the same basic process

do it formats the data that has come from the authoring house, and adds the AACS encryption key if it has not already been implemented. That was, early on in the format’s life, a bit of a bugbear, creating a huge time lag on already tight schedules, but speeds have been increasing and can now, apparently, be done overnight and not take days as before.

“The write strategy necessary for pit formation on all Blu-ray LBRs is known as castle-type or land-pit-land adjustment-method write strategy,” says Eric Carson of DCA. “Since each Blu-ray capable LBR offers slightly different recording methods, DCA has chosen to offer two different hardware encoders, each with its own write strategy functionality.”

The DCA’s B1 series encoder board with PCS2e write strategy is capable of making high precision adjustments to pit edges and amplitudes, and serves as an economical option for LBRs with built-in write strategy, such as the SDAD PTR-3000 machine. The internal write strategy capabilities of this machine need only standard pit-land structures as an input, with castle-type write strategy being generated by the machine on the fly.

DCA also offers the Pit O’Resc encoder board with PCS2e write strategy, which can natively output castle-type write strategy for LBRs that need this signal source directly, such as the Singulus CrystalLine, M2 SQM and ODC Nimbus M8100.

Eclipse provides a range of check systems as well as its encoders and, says Bob Edmonds, the company’s VP sales and marketing, “virtually every major title Blu-ray Disc mastered in the world is touched by our EclipseSuite BD software. As part of the mastering process, our pre-mastering software scans for errors and adds the AACS copy protection before images move to the PTM.

Our software discovers many authoring problems on BD images – some can be fixed, others need to go back for re-authoring. With the high cost of BD mastering, this is obviously an important step.”

To support the PTM method for BD, Eclipse uses a method of pulse shaping called pulse width modulation (PWM). “Mastering the Blu-ray format on a PFM system is virtually impossible without this technique,” says Edmonds, “as DVD pulse shapin
required only simple timing and amplitude edges adjustment to make pits slightly longer or shorter. With the PTM process, more complex pulse shaping is required to control the duty cycle of the laser. Eclipse’s technique uses as many as 13 parameters to describe each pulse shape. The PWM feature in Eclipse’s ESP-7000 format, he says, provides a 16-picosecond timing resolution for precise pulse shape control. Additionally, the ESP-7000 can account for inter-symbol interference (the effect and distortions caused by adjacent pulses) by applying different pulse shaping settings for various pit/land-pit combinations. With this additional control, pit lengths can be finely tuned and overall jitter reduced, resulting in higher yields.

With DVD, the main method used for glass mastering was photore sist, except for ODC Nimbus, which has the claim of having developed photore sist early and moved on to dye polymer for DVD (see company profile, One to One issue 219, April 2009). Similarly, though early on in the format’s life, it was unanimous that photore sist was unsuitable for Blu-ray. M2 has worked out a photore sist system for BD.

As with so much else in optical media, the challenge with each successive format is that of getting more data on the same size disc; smaller pits more densely packed. Pit shape is also an issue and that’s why everyone except M2 says photore sist doesn’t work, being a light-based laser system the size of the beam (the cutting beam profile) that creates the pit cannot be made small enough.

Sato adds, requiring a few basic steps: cleaning, sputtering of the inorganic resist, and the laser cutting, and the developing. The cleaning and plating are essentially the same as for DVD and even CD. One crucial element that makes the system unique is its use of silicon wafers (everyone else uses glass), while some people point to this as an extra cost, Sato believes it means rather that the reliability and stability of the system means cost-effectiveness through reduction of waste.

The PTR-3000 has been a 405-nanometre laser beam, as with DVD but with a patented, special blue laser diode and this as a heat source, coupled with the inorganic resist, is what the company says makes it possible to create the smaller pits required for BD. Other key technology advantages include what SADAD calls the FUH (pick-up head), an all-in-one optical unit that is ‘plug and play’ with a reduced optical path for higher stability. The spindle/slide unit uses air bearing for more accurate transport of the wafer by robot.

“Once the process is optimised the time an operator needs to spend with the machine is limited,” says Sato. “Because the optics are all in one inclusive unit with a smaller footprint, replacements are quick and easy, so that also means less downtime.”

The PTR-3000 is compatible with either DCA or Eclipse encoding systems.

SINGULUS MASTERING HAD TRIED TO MAKE PHOTORESIST WORK for Blu-ray early on, explains the company’s CEO Guido Dalessi. “There are two important issues with mastering: one is accurate control of the mechanics so the pits are in the right place, with bigger pits you can allow more variation but for Blu-ray there is more restriction as the pits are so much smaller. The much smaller pits cannot be accurately created with a light source and photore sist, so that is why we changed to PTM.”

It was not a decision taken lightly he points out. “Of course we would have loved to stay with photore sist because this we have known for the past 20 years. Learning a new process means you have to forget everything you knew, throw away all that experience and start from zero to learn all the ins and outs again. That took us a lot of time to get where we are today.”

Singular Mastering launched its CrystalLine mastering system at the Long Beach MEDIA-TECH Expo in 2007 that followed a period of working with SDAD to learn the PTM technology (much as Sony worked with Singulus to help them develop a replication system for BD in order, as Sony DADC CEO Dieter Daum said on many occasions, to help stimulate the industry).

The system works on a ‘Glass Substrate in – Finished Glass Substrate out’ principle: there is a wet station for cleaning, developing and DCM measurements; a single chamber, three target sputtering units for applying the PTM recording, and nickel layers; and a new LBR for the actual recording process. “The use of the Phase Transition Mastering (PTM) process, combined with advanced wave shaping technologies, enables the use of the proven 405nm solid state laser on the new LBR. The signal encoder incorporates advanced wave-shaping technology feeding the laser.”

“There was just no way to use photore sist and that’s why we went to PTM,” Dalessi explains. “PTM can utilise different materials that behave in the same way, the chemical composition of the Sony PTM is different from ours but it displays similar behaviour when you expose it to a laser.” Simply put, with photore sist, you turn on the laser and the disc rotates, and that’s how data is written to the glass master. With PTM, the laser heats up the material and then the laser is switched off and it cools down and that’s how the pit is created.”

Dalessi also agrees that the actual steps for glass mastering are very similar, whatever the format or actual system: “With photore sist there is a cleaning stage, developing, sputter coating, and then sputtering. With PTM you have disc cleaning, then sputtering of two layers, one is silicon and one is the PTM material. Then there is a third stage, which is the sputtering that was always done.”

The crucial part of BD mastering, says Dalessi, is the laser modulation. “With photore sist, to write a pit the disc rotates, the laser switches on and off and is an exposing process with light. PTM is a heat process and heat accumulates, so the critical part is how to induce the heat to material – how to get it in – and how to dissipate it – how to get it out.”

With photore sist, the material will react to the smallest amount of light, so the spot size can grow only so low PTM however, is not sensitive to low heat intensities: “It will only react after a certain level so the effective spot size that you can make is much smaller. The laser itself is the same as before, so that is very convenient.”

Regarding encoding, says Dalessi: “The CrystalLine is developed for working with every type of encoder that is commercially available. There are some small differences between systems, but every existing encoder should do the job. We simply follow what our customers prefer and that is what we deliver with the CrystalLine.”

At the time of writing, Singular Mastering had six systems in the field in the US and Europe and is hoping to ship its first machine to Asia at any time now.

For ODC Nimbus, going with dye polymer only made sense as that is what the company has been working with for some time and, unlike Singular Mastering’s experience, didn’t have to throw out knowledge and relearn everything. As ODC Nimbus president Tony Holden states firmly, “The PTM is a good system but, we believe we are ahead of any other company in BD mastering.” The company started off with the M8000, based on Nimbus technology and this year brought out its M8000 for Blu-ray.

Holden too, says that it is not possible to use photore sist for Blu-ray glass mastering. “Photore sist is
inherently grainier, and as you get smaller and smaller pits the grain remains the same size so it’s more significant. Companies tried to use it early on and went for shorter and shorter wavelengths with the laser but the limiting factor is the recording medium itself.”

Working with familiar technology, developed back in the 1980s, is a big advantage for the company, he points out. “ODC Nimbus has been using dye polymer for some time and it transpired the smaller feature sizes didn’t cause us a problem – we just reformulated the dye polymer and went to a shorter wavelength laser – 375 nanometre wavelength laser compared to the 405 that we used for DVD. A shorter wavelength laser means you can make smaller features for a given length, so with our high resolution dye polymer and a 375nm laser we basically use the process that we used for DVD and even CD, with two very small changes.”

Again, says Holden, the process is very similar to that of DVD: “We start off with a piece of optically polished very flat glass; we do multiple cleaning processes as even brand new glass isn’t clean enough for what we need. We then spin coat it with a dye polymer to a specific thickness, and finally we’ll bake it so that we end up with a piece of glass that’s essentially got a dye polymer film on it, like a very thin plastic film.”

That plastic film is where the pits are cut, as with photoresist, but with one major difference: “We don’t go all the way down to the glass. With photoresist it is exposed and then washed away down to the glass, which makes very sharp pit edges. Our dye polymer is thicker than the depth of the pits that we want to cut in it. That way we have the latitude to make pits deeper or shallower if we want to.”

That, combined with the company’s patented DRAW (direct read after write technology) means ongoing quality control, Holden explains. “If a condition changes, say the objective lens gets dirty, because we’re playing back what we’re cutting, the mastering machine can recognise that something’s changed and it knows that the pits are too shallow so we compensate for it no matter what happens.”

Once the pits are finished, the glass master has a layer of nickel placed by vacuum deposition. “The real purpose of that nickel is to provide a conductive layer because you need some sort of electrical connection in order to make the electroplating process work.”

The DRAW process is what gives the M8100 a real edge, Holden believes. He won’t discuss yields, but instead says this advantage translates into more throughput. “Within a master there is not only the basic data, there is also barcodes and visual character information. DRAW means we can cut just the basic data first and monitor it all the way, if there is any defect we can abort that job.”

“If one in 20 masters had a defect and we abort that job, we won’t have wasted any time writing things like the label. Many people will cut the label first, which takes a significant amount of time – and that’s wasted time. Once we’re absolutely certain the job is good then we’ll put the label on. That means if you take one of our LBRs and one of our competitor’s, both with the same yield, our machine will have a higher throughput. His one in 20 is rejected but that’s only after a stamper or even a replica has been made.”

ODC Nimbus sold four BD mastering systems last year, and announced at the MEDIA-TECH event in April that it had just agreed the sale of a system to Opticon in Greece, a new hi-def mastering facility.

As with SDAD and Singulus Mastering, ODC Nimbus’s systems are designed to work either with DCA or Eclipse encoding.

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GUIDO DALESSI, SINGULUS MASTERING
working with a known quantity. Martin Brown, VP optical disc systems at M2, states firmly: "We have indeed succeeded in making BD on photoresist using a modified process method, the details of which I cannot disclose at this time."

Apart from the formulation of the photoresist, he adds, the LBR optics are the only real change from the original SQM system for DVD, which was introduced at the 2004 Replication Expo in China.

The company introduced its SQM with dual LBR for HD mastering in 2007. At the April MEDIA-TECH show in Frankfurt, M2 announced a sale of the system to existing customer Synchronicity Mastering Services in Salt Lake City. The fact that the system uses photoresist was one of the big attractions, according to Synchronicity's president Tom Whitworth, who plans to master recordable BD initially. "Photoresist means we get better yields and a smoother pit shape, which is good for replication, particularly with recordable media."

That is a big plus of the system, Brown explains: "By continuing with photoresist – the same basic materials, but modified – this enables us to create the smaller pits required. It also means we can use the same basic machine, so we have not had to use massive resources either on the human resources or finance side. The SQM has a good name, and the hardware is basically the same as the 20-plus systems already out there. We used photoresist for HD DVD and those systems worked well. The jump from HD DVD to Blu-ray is smaller than that from DVD to HD DVD." The use of photoresist also makes for a more cost-effective solution, says Brown.

M2's SQM uses DCA encoding equipment.

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"THE REAL PURPOSE OF THAT NICKEL IS TO PROVIDE A CONDUCTIVE LAYER BECAUSE YOU NEED SOME SORT OF ELECTRICAL CONNECTION IN ORDER TO MAKE THE ELECTROPLATING PROCESS WORK"

TONY HOLDEN, ODC NIMBUS

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