Demystifying the drive

By Dr. Andrew Dumbill, CTO DaTARIUS Group

For the latest generation formats to be robust and reliable in use, the consistency and conformity to standards of both drive and media is critical – significantly higher than that for DVD. This demands even higher standards of manufacturing excellence from the media producer.

Compliance with the standards demands certainty of measurements taken from the media. Test systems employing drives are the ultimate verification of compliance to the standards. However, these test systems are only as good as the drive they use, as the drive is the interface device between media and the measurements taken – any variation will lead to uncertainty on results. The reference test drive, therefore, is a critical part of the process both to ensure disc manufacture is within limits and to fine-tune the manufacturing process to optimize yields and minimise cycle times.

The evolution of reference drives

Since the earliest days of this industry, with the advent of CD, there has been a need to establish – with certainty – media quality. Early test systems relied totally on consumer drives as the basis for their measurements. This evolved to more robust industrial mechanics but, even now, there are consumer grade components at the heart of most CD test systems. This caused many additional challenges, and uncertainty in results made it difficult to predict what discs would play on consumers' equipment.

Calibration discs were quickly introduced but it became clear that this alone was not enough: all test drives (and therefore test systems) could be made to read the same on a calibration disc. But what about discs that were not close to the calibration disc standard?

With many different disc manufacturing processes (mastering, stampers, moulding, etc), what was ultimately crucial was allowing disc producers a tool that could safely judge their process – how close it was to failing and if failing why? Having test systems say 'no disc detected' or 'result failed' was not enough. The test drive had to play, if at all possible, even the most badly produced discs so that a manufacturer could determine what was wrong and fix it.

What also became clear was that if a series of test drives had significant differences between them no amount of calibration would hide this when testing a range of 'real world' production discs. The effects of these inconsistencies were limited but occasionally a combination of certain disc characteristics and drive anomalies would reject an in-spec disc (close to the limit) and, even more worryingly, pass a disc that was outside limits.

Around the time of the birth of DVD, a new parameter became established as a key factor in judging disc quality: jitter (the stability of the data played from the disc). This parameter has since been used to match test drives and to be the final check on both drive and disc quality. Unfortunately, jitter is not easy to control as many effects – both drive and disc – contribute. The values seen from drive effects can simply mask (or offset) effects seen directly from a disc.

For example, in DVD-5 the regular values seen are in the 6% to 7% region but failure (to specification) is 8%, giving a very tight window. Two 'reference' drives can often show up to 1.5% difference between them on the same disc, so a 7.5% disc can pass on one drive while failing on another. This highlights how critical this measurement is for drive and disc makers alike.

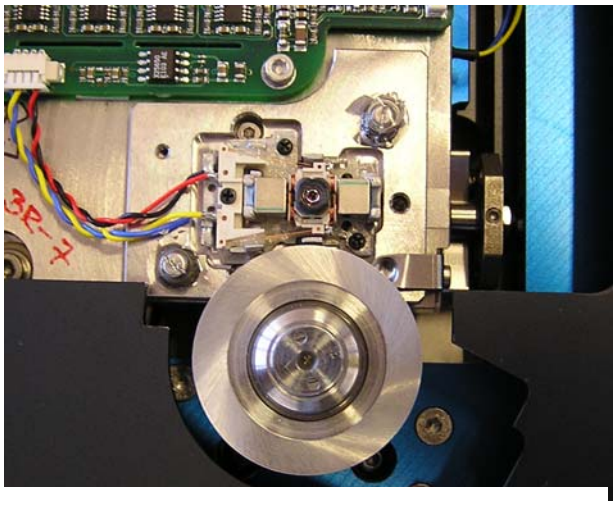

Figure 1: drive OPU

With the advent of DVD the standards bodies decided that a standard test drive was required. Pulstec took up the challenge (after being responsible for the early laboratory test systems) in producing a drive component (SDP series). Initial inconsistencies between SDP drives required a number of iterations on the OPU (optical pick up), but two years into the new format unparalleled levels of consistency (and playability) were established.

The key factor

How was this possible? The key factor turned out to be the OPU. This device is the critical part of all drives, ultimately defining the relationship between the drive and the media. Other parts had effects on general measurements (for example, the spindle motor directly affects radial noise) and the mechanics generally needed to be of the highest standard but the OPU was, and remains, critical. This ultimately also impacted the most on jitter when comparing a 'good' low jitter drive to a 'bad' high jitter drive.

Figure 2: DaTARIUS reference drive: driveCube

The real challenge in creating a standard drive was at last seen to be controlling and carefully determining key parameters of the OPU. As long as certain rules were observed, other reference drives could be made to match a 'standard'.

The main OPU design-critical parameters for DVD (which hold true for BD and HD DVD) are as follows:

- Spot Quality (size and shape)
- Actuator Performance
- Laser Power Stability
- Component Alignment and Thermal Stability
- A Final Quality Check

Spot Quality

The size and shape of the laser spot is directly related to the HF pattern produced by the OPU. As a simple example, if the I3 pit is too small, it produces only a very small deviation to the HF signal, conversely, if the I3 is perfectly normal but the focused spot is slightly too large then the same effect occurs – an extreme example would be trying to read a DVD using a CD OPU; we would see very little information.

Therefore, for every OPU it is important to measure several parameters related to the spot shape and quality.

- Spherical Aberration: a measurement of symmetrical distortion of the laser spot – this effect is made worse by substrate thickness variations
- Coma: a measure of the asymmetric distortion of the laser spot that looks comet-like (hence 'coma'). This effect is made worse by disc tilt, and has a large effect on the jitter in the HF signal

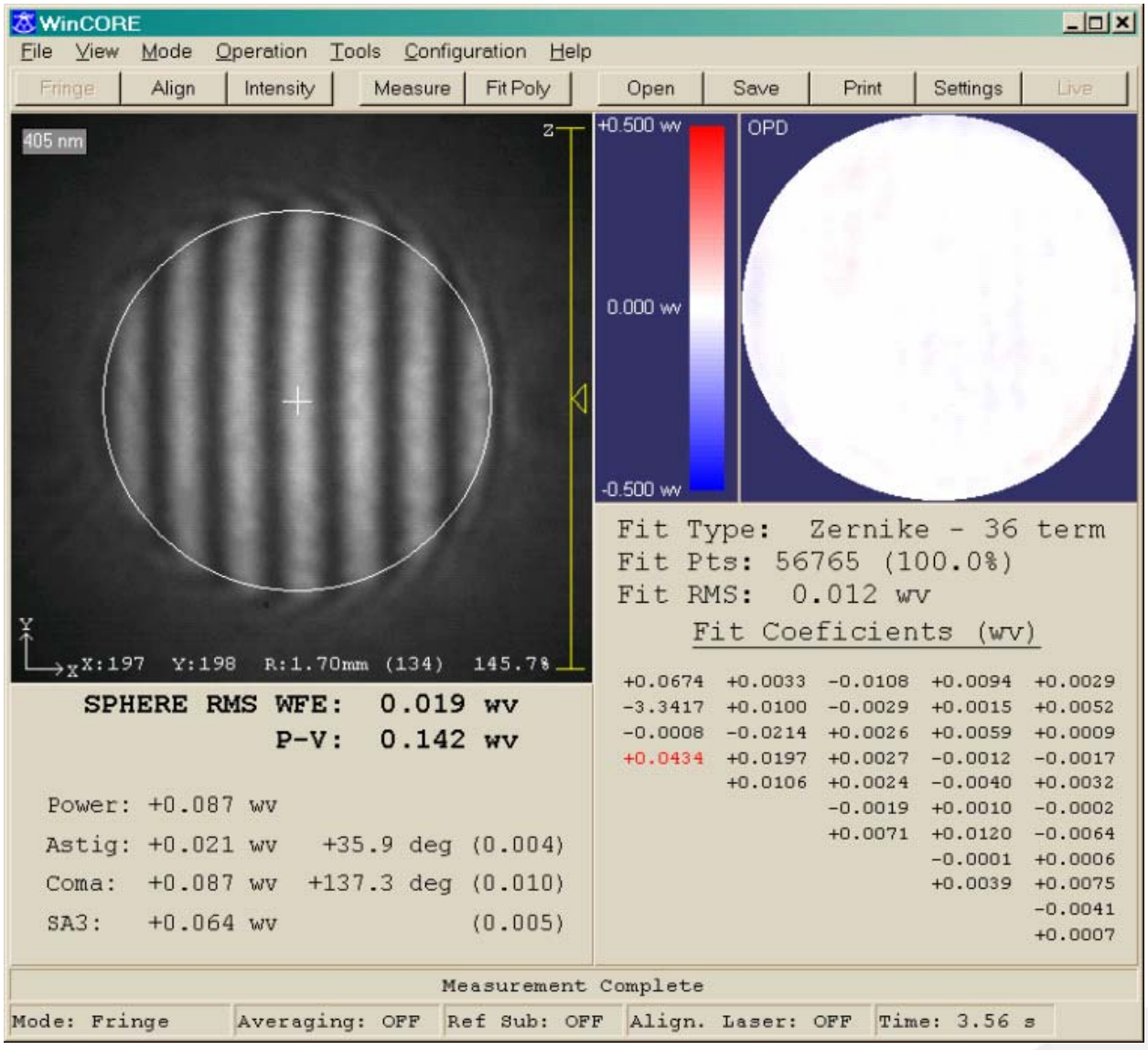

Figure 3: Beam only 19 milliwaves RMS

- Astigmatism: a distortion of the spot shape as a result of different focus points

- RMS Wavefront error: – A key parameter controlled in DVD, BD and HD DVD specifications
- Birefringence: changes in sensitivity at different polarizing angles as measured through the optical path

Below is a diagram showing the test results from a development OPU – It fails the RMS requirements from BD specification (0.033λ), because the final lens quality is not good enough.

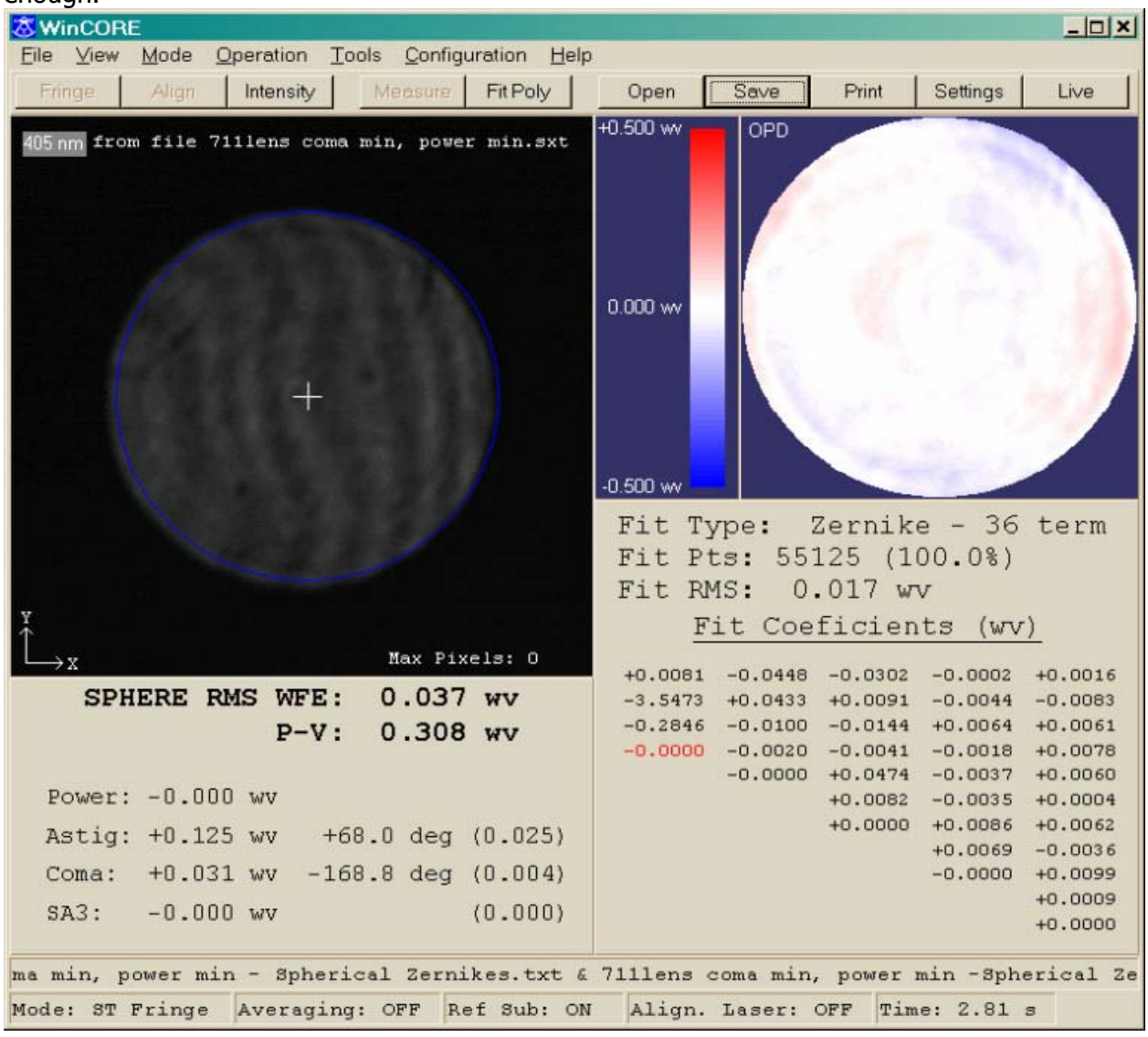

Figure 4: lens only 37 milliwaves RMS

Actuator performance

The actuator is the part that moves the lens, providing focus and tracking. Several different types of actuator have evolved over the years – from early swing arm types (CDM4), to slip stick designs (Pulstec SDP on DVD), to the latest 4-wire designs (high-speed DVD and BD).

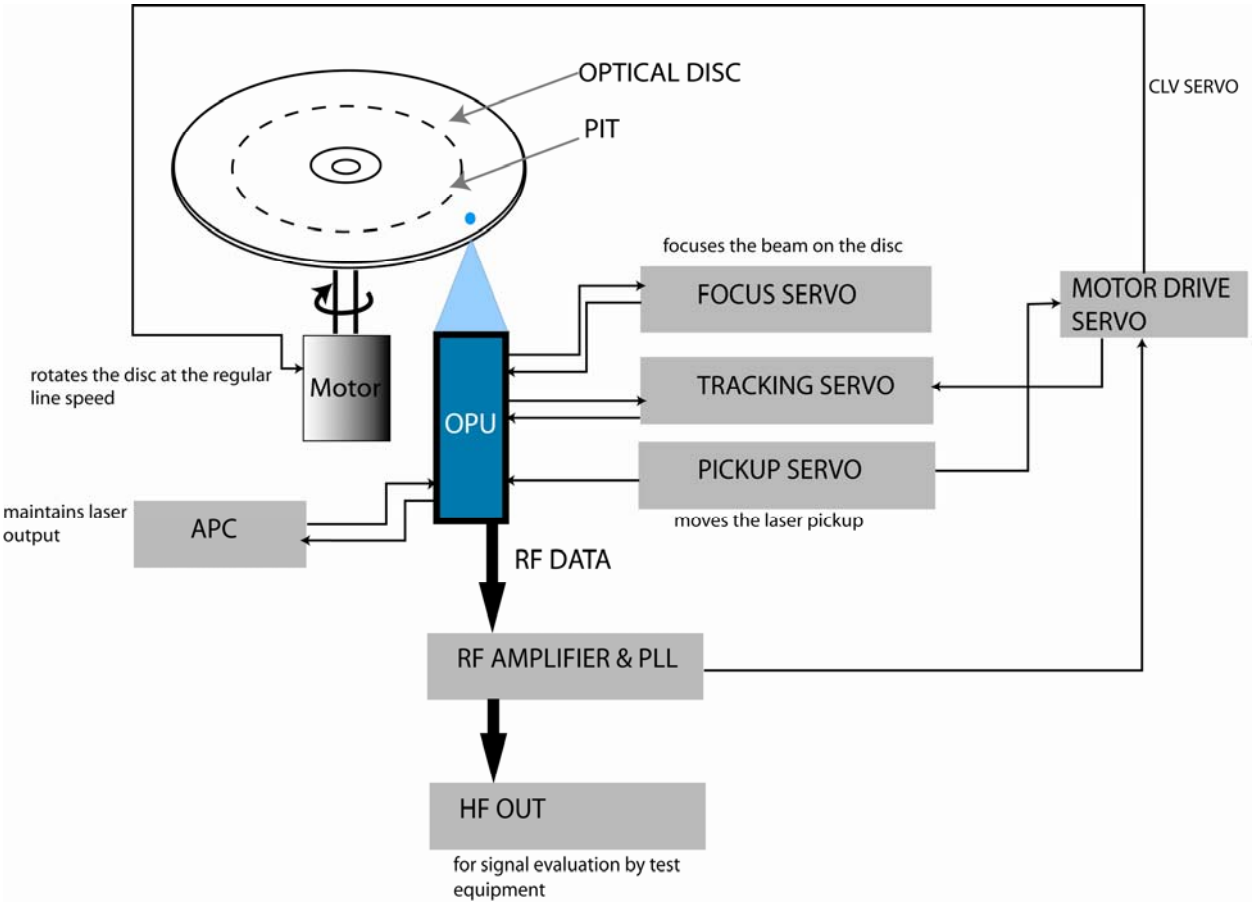

Figure 5: block diagram of drive

The key parameters to measure for actuator performance are:

- Focus and tracking transfer functions: looking at the gain response of the actuator over a large frequency range, to ensure that its performance will allow the drive to maintain focus and tracking. Small errors in the positioning of the final lens in the actuator, a slightly bent wire, a failure in the focus or tracking coils, will be immediately evident in the transfer function (BODE) plots

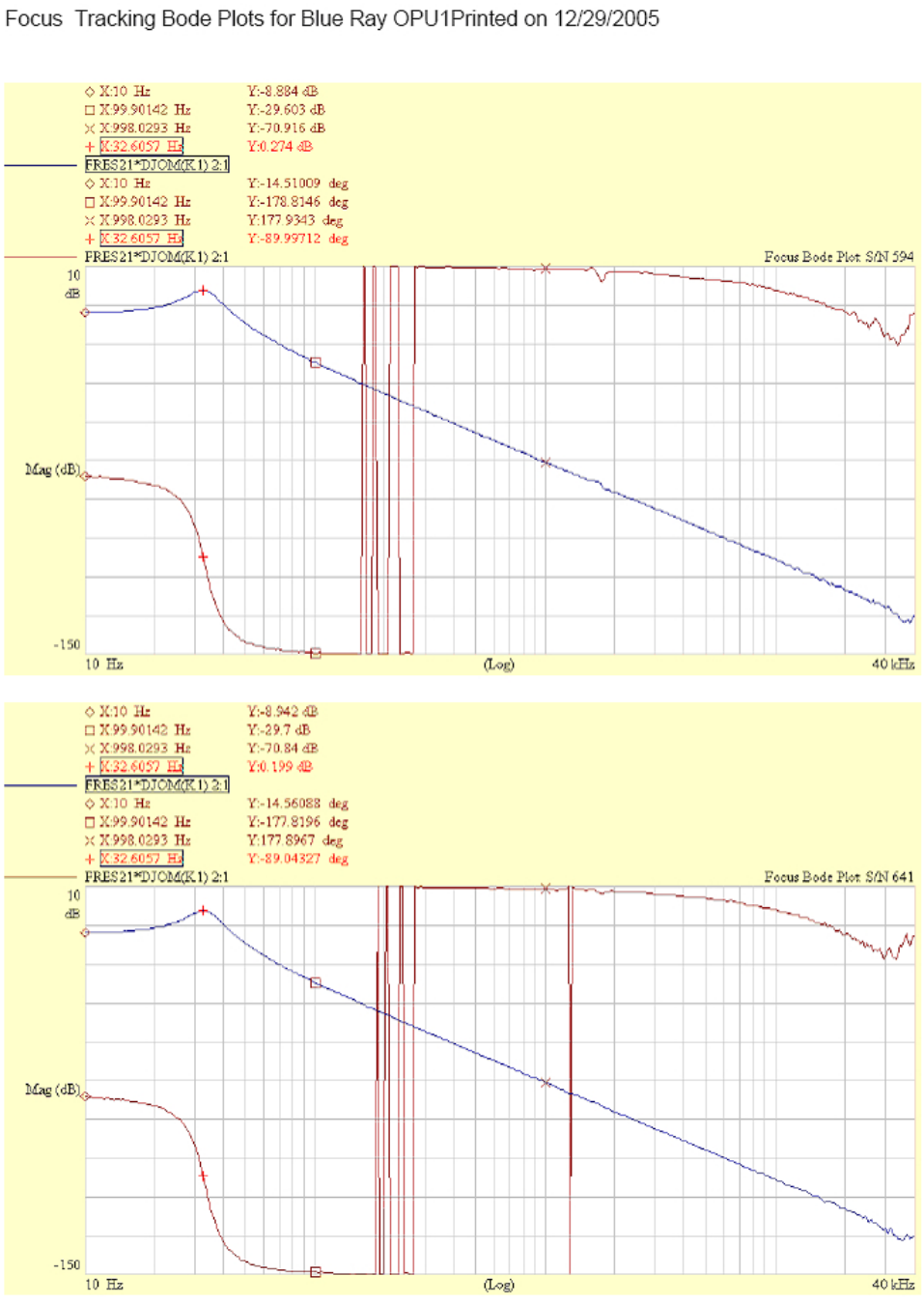

Figure 6: Focus tracking bode plots for Blu-ray OPU

- Rim Intensity at the Exit Pupil: the rim intensities are specified for BD, HD DVD (and DVD). Failure to meet the rim intensity specifications will lead to variation between OPU

HF outputs, especially when a disc has a high (near or beyond specification limit) eccentricity. Because the actuator moves the lens within the beam, the rim intensities will change, hence the intensity distribution at the spot changes and the resulting HF output from the OPU changes

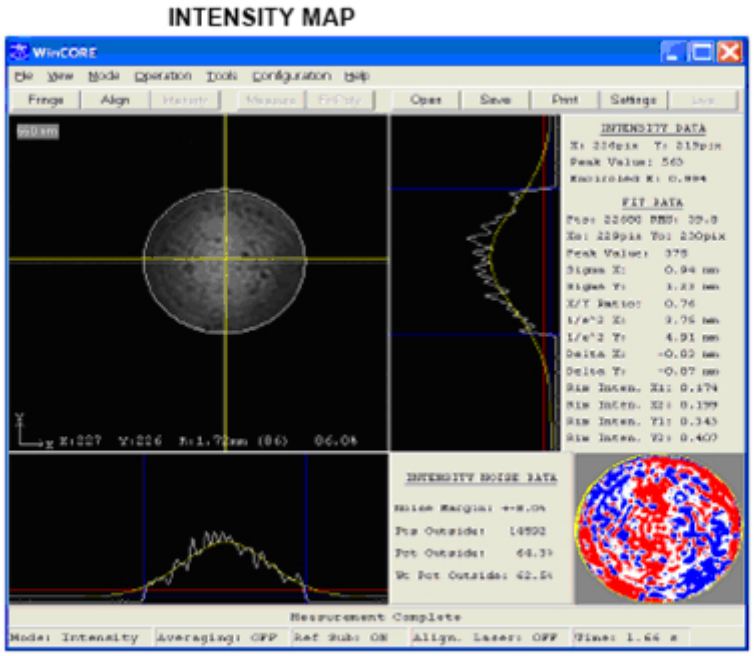

Figure 7: Rim intensity diagram

.

- Tilt over Stroke: this is the amount that the lens tilts within the beam during vertical (focus) movement. Only a small amount of tilt is allowed, otherwise this will induce additional coma into the focused spot, dependent on the focus position of the lens. This will directly influence the jitter in a way that would not be clear to the disc manufacturer e.g. if we have two discs, both with same jitter, but one has more vertical run-out (but still within specification), this could result in jitter being shown much higher on the drive with the large tilt over stroke.

Laser Power Stability

Laser power stability is monitored during a production burn-in cycle to ensure that this is closely achieved. Significant variations in laser power can lead to problems with tracking, focusing, etc, because the electronics expect to see a signal in a certain range, and discs with a given reflectivity.

Component Alignment and Thermal Stability

The alignment of all components is closely monitored. It is acceptable (depending on design) for slight misalignments of components (which could result in a tracking error) to be compensated within the electronics. However, it is important to ensure that at the build point the alignment is correct to give the greatest margin of tolerance for the OPU during its lifecycle.

Each OPU also undergoes thermal cycling in a climate oven, and testing is carried out at various points during the cycle. Usually, this is only done during the design and development phase of the OPU, but a basic check for each OPU is useful to determine any production build problems.

A Final Quality Check - Jitter

All the efforts and work to check component and build consistency is aimed at ensuring that all OPU and drives behave the same. As above, jitter is the parameter that appears to vary most between drives and is highly significant for the disc manufacturer (equally so for blue formats). Therefore, all OPUs are tested to ensure that jitter is within a certain range on a range of discs exhibit a wide variety of problems: tilt, vertical deviation, substrate variation, and so on.

Meeting the challenges

By being very careful in the design of the test drive – and in particular the OPU – the industry can achieve a consistency of performance that will lead to unparalleled levels of playability and stability for the end user.

With increasing challenges to optical media storage from the Internet and hard drives, this need for the highest possible standard for the future media has never been more critical. Test systems will play a vital role in ensuring that the consumer sees these formats as reliable and robust; this, in turn, places ever more demands on the reference drive and, subsequently, the OPU.

About DaTARIUS Technologies GmbH

The DaTARIUS Group is a global company focused on providing solutions throughout the optical media manufacturing industries. DaTARIUS developed the first commercial CD test system and has over 20 years' experience in the manufacture and distribution of equipment for inspecting, measuring and optimizing at every stage of the optical media manufacturing process.

DaTARIUS is unique in providing equipment for the entire production process right through from pre-mastering to print and packaging. Its products are suitable for every optical media format – pre-recorded and recordable – from CD & DVD through to the new blue laser BD and HD DVD formats, and other emerging formats such as HD VMD.

In addition, DaTARIUS also develops and supplies process optimization equipment, such as sprue recycling and mould temperature regulations systems. This broad product range is supplemented by consulting and training services.

Beyond optical media, DaTARIUS, in partnership with InPhase, is developing quality control equipment for the next generation of holographic formats.

With headquarters in Reutte, Austria (R&D, sales and service), and regional offices in America Germany, Japan, China and Hong Kong, the DaTARIUS Group has a global team of 100-plus employees and partners with an extensive sales and service support network covering every major market of the globe: North America, South America, Europe, the Middle East, and the Pacific Rim.

For more information on the company and its products, visit www.DaTARIUS.com

DaTARIUS Contact Details:
DaTARIUS Technologies GmbH
Anton Maria Schyrle-Str. 7
A-6600 Reutte
Austria
Tel: +43 5672 2060
Fax: +43 5672 206 8000
Email: europe@datarius.com
www.datarius.com

Cédric Collard, Marketing Manager
mail to: cedric.collard@datarius.com
tel: +43 5672 206 430