

# **Ultra Violet - The Key to Successful DVD and CD Mastering**

## **Introduction**

In early 1994, Nimbus Technology & Engineering was given the challenge of designing and building a mastering system for a new high density optical disc by Toshiba and Time Warner. The DVD mastering system became a reality at the start of 1995 and has been used in continuous production trials at WEA Manufacturing plant in Olyphant, PA. WEA now have two Nimbus DVD mastering systems in actual production.

Nimbus was asked to provide a production system, not a Research and Development tool. Our decision to move to an Ultra Violet Laser was in response to the request for maximum production tolerances which we did not and do not believe a Blue Laser system can provide. It was also essential that the equipment should perform excellently both for DVD and CD. The development program undertaken by Nimbus began by identifying those elements of the standard Nimbus Blue Laser system which already performed to the level required for DVD mastering, and those which needed development.

## **Resist Master Preparation Line**

Our investigation started from the practical consideration that glass for CD and DVD should be able to be coated by the same equipment. No manufacturer wants to maintain separate lines for such closely related product.

It proved possible to produce the thinner coating of photoresist required for DVD mastering using the same chemicals and the same dilutions as for CD mastering. The thinner coating of between 100 and 120 nanometers was achieved by simply changing the final spin speed of the Spin Coater.

## **Surface Analyser**

The Surface Analyser is a unique process tool which ensures that only 100% good glass is passed to the Laser Beam Recorder for mastering. It checks the coating for thickness consistency and defects. It was possible to make this a dual standard analyser by changing the wavelength of the red laser within the head assembly.

No other changes to the Resist Master Preparation Line have been required.

## **Laser Beam Recorder**

The frictionless air-bearing design patented by Nimbus twelve years ago which replaces the friction drive and lead screw systems of other LBRs required no mechanical re-engineering to achieve the DVD track pitch of 0.74 micrometers, with a maximum deviation of  $\pm 0.03$ . A major industry research laboratory recently verified the track pitch stability of our DVD masters to be  $\pm 0.007$  micrometers, which is four times better than the specification.

Nimbus' decision to use an Ultra Violet rather than a Blue Laser for DVD mastering has been covered in the publication entitled Blue vs. UV - The Challenge of High Density Mastering. The Krypton-Ion Ultra Violet Laser chosen has a wavelength of 351 nanometers, and therefore requires new lenses and modulators optimised for this wavelength. Early trials showed short term fluctuations in pit

volume which we initially attributed to variations in recording power and laser noise. However, it was soon proved that the closed loop system for control of recording power was delivering constant energy to the final objective. As a precaution a noise eater was added to the optical path which uses our own drive electronics for wide bandwidth and minimum power loss. This noise eater was originally developed by NTE for our Wobble Groove LBR. When mastering CD-R even low levels of laser noise adversely affect the consistency of the groove profile. Finally our research showed that short term fluctuations in pit volume are a function of focus control. Conventional focus systems are not good enough to work with the very shallow depth of field which is a consequence of the 0.9 numerical aperture needed to produce the small recording spot required for the DVD.

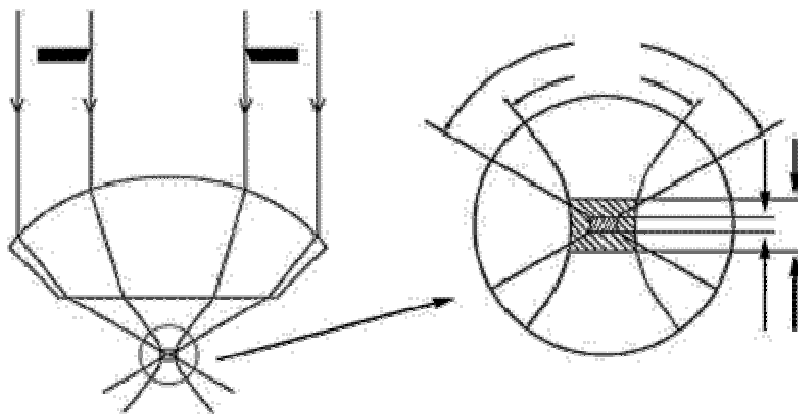
## The Focusing System

The Red Laser focusing system used on the standard Laser Beam Recorder and which is sufficient to maintain focus when mastering CD with a Blue Laser cannot by itself maintain focus accurately enough to cut DVD pits. However it is maintained on the Ultra Violet LBR since it stabilises focus of the final objective lens when the UV laser is off for long periods, as is the case for lettering bands. This primary focusing system is supplemented by a secondary system new to the Ultra Violet LBR which looks at the actual recording beam.

A small amount of light is reflected from the surface of the glass back through the final objective lens into a detector system. Small variations in focus are registered on the detector and are automatically corrected. Light returning from the glass in this fashion is at an extremely low level, and requires signal processing performance only possible using the very latest electronic devices.

It is our experience that a secondary focusing system of this type monitoring the recording spot is required to master DVD successfully. Even with an Ultra Violet laser, it is necessary to use a lens with a numerical aperture of 0.9 to produce a recording spot small enough for DVD mastering and a wide process window. Using a numerical aperture this high makes for a very shallow depth of field - less than a quarter of that available when mastering CD.

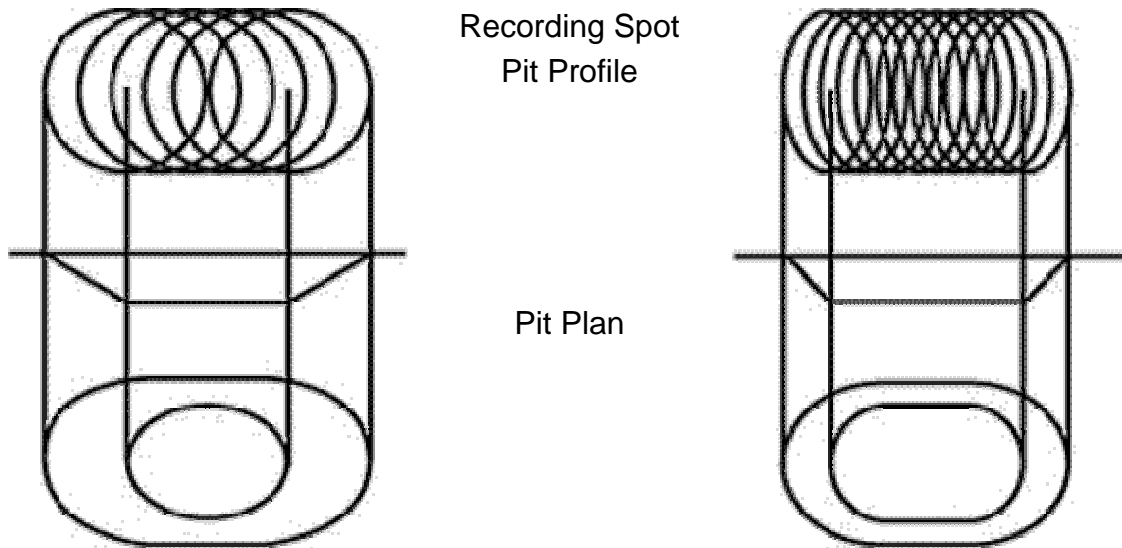
A third feature of NTEs focus control is continuously to monitor the intensity profile of the spot and use this automatically to calibrate the focus system. This closed loop system generates optimum focus and eliminates the need for manual calibration or focus offset adjustment.



Function of an Aperture - reducing beam size increases spot size.  
Higher numerical aperture needed produces shallower depth of focus.

## Mastering CD with Ultra Violet

For mastering standard density CD using an Ultra Violet laser, the recording spot needs to be enlarged in order to produce pits wide enough. It is possible by adding an aperture to the optical path to widen the spot across the track to produce the right pit width, while maintaining the finer resolution used for DVD mastering along the length of the pits, effectively creating an elliptical spot. The shape, size and position of the aperture can be designed to suit a wide variety of process conditions. The elliptical spot results in a much higher level of control over the pit ends, and a significant improvement in the jitter characteristics of the disc. The use of this aperture makes the switch between CD and DVD mastering quick and means that the Ultra Violet LBR is optimised for both densities.

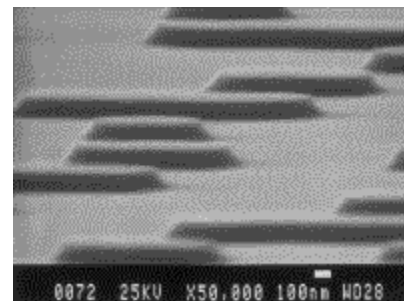
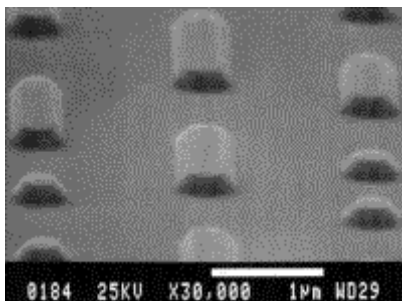


### Autodeveloper

The Autodeveloper controls the volume of the pits during the developing process by monitoring the strength of the first order diffracted beam. The angle of this beam depends upon the track pitch: it has therefore been necessary to make a dual standard head which is capable of reading both CD and DVD pits.

### Upgrade path

The number of changes to the standard mastering system is relatively small, and involves no mechanical modifications. This makes the upgrade from a Nimbus Blue Laser Beam Recorder to an Ultra Violet one possible with minimum downtime for customers with a single Laser Beam Recorder.



Ultra Violet CD cut, magnification x 30,000 looking along the track      Ultra Violet CD cut, magnification x 50,000 looking across the track

These SEM (scanning electron microscope) images of a stamper show the extreme control of pit ends possible by using the aperture and which in these examples produced jitter values of less than 10 nanoseconds. One of the significant benefits of using an Ultra Violet laser clearly seen above is the uniformity of pit cross section even for the shortest pits (this leads to an increase in the value of I3) and the smoothness of the pit walls. As always the photoresist process makes it possible to create pit geometry optimised to the downstream processing and replication requirements of each plant.