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# "A STANDARD DISK FOR CALIBRATING HEAD-DISK INTERFERENCE MEASURING EQUIPMENT"


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# A STANDARD DISK FOR CALIBRATING HEAD-DISK INTERFERENCE MEASURING EQUIPMENT

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Abstract - A technique is described for producing standard disks for calibrating head-disk interference measuring equipment. The technique is more accurate than conventional methods, and yields disks with a much longer useful life. The method used is to sputter a group of small pads of tungsten onto a conventional oxide-coated rigid disk. The pads have a range of heights similar to the anticipated flying height of the head-disk combination under consideration. A glide-test head is then flown over the pads, and accurate thresholds are set according to the head output signal. It is shown how the thresholds can easily be set to an accuracy of $\pm 1\mu$".

## INTRODUCTION

Flying heights as low as $10\mu$" are now in use in disk drives, and one burden this places on the disk manufacturer is that of burnishing the disk coating low enough so that head-disk interference (HDI) does not occur. The only way to check when burnishing is complete is to fly a glide-head across the disk and check that the piezo element does not show any "hits". Some companies set the HDI signal threshold limit at some arbitrary level exceeding the "grass noise" from a "standard" disk. Others use trial and error with disks which were "dinged" and worn down with either a burnish head or an HDI head. The protrusion is measured with a surface analyzer and the HDI threshold is set with these "calibrated" protrusions.

The latter method is a good technique, but it can take a considerable time to wear down and measure the protrusion, and it is difficult to ensure that the protrusion does not wear down or cause a head crash during calibration. The work reported here describes an alternative method of generating standard HDI disks, whereby controlled protrusions are deposited by sputtering onto a disk.

## DESIGN APPROACH

It was apparent that most companies are still using the heavily loaded (>225 grams) 3330 type flyers in their burnishing and HDI testing. The decision was therefore made to use non-lubricated disks with 3330 type HDI heads in this study, and, although the same technique can be applied to Winchester technology, the exact implementation would probably be different due to the differences in the air-bearing characteristics.

It was proposed that a total of twenty-four pads be deposited onto an oxide-coated disk by sputtering, in four groups of six pads each. The pads were to be 0.020" in diameter, which is approximately 1/3 the width of the air bearing surface, with the inside pad at 4.10" radius and the outside pad at 6.4". The height of the four groups was to be approximately 9, 11, 13, and $15\mu$", chosen so as to cover a range of glide testing from ~ 8 to $16\mu$". The material to be deposited was hard chrome because of its hardness and ease of deposition, and would hopefully meet the goal of 30 hours HDI disk life.

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The HDI crystal head would then fly over the pads of different heights at the same radius. Thus, one can monitor the HDI signals from each of the four pads and adjust the HDI signal threshold detector to reject asperities higher than some preselected height.

After the first disk was sputtered, the number of pads was reduced to eight as shown in fig. 1 because of the problem in simultaneously depositing the six pads in the radial direction. It was difficult to deposit pads of the same height over 2.3" with the sputtering equipment used in this study.

## PAD MATERIAL SELECTION

Chrome was initially chosen as the pad material because although it is quite hard and durable, it is softer than the aluminum oxide HDI head and so should not cause head wear. Unfortunately, the pad proved to wear down too fast when the outer air-bearing surface of the HDI head was flown over it, as indicated both by a reduction in HDI readback and by a surface profile trace.

Several other materials were therefore tried: titanium carbide, tungsten, nickel vanadium and tungsten carbide. The rate of wear varied from $0.02\mu$"/hour for tungsten to $24\mu$"/hour for titanium carbide. This led to the choice of tungsten as the most suitable pad material, and so calibration disks were produced, each with several different heights of tungsten pads, as shown in the profile traces in fig. 2.

## HDI HEAD SIGNALS

The purpose of this study was to create HDI disks that can be used in accurately calibrating test equipment for

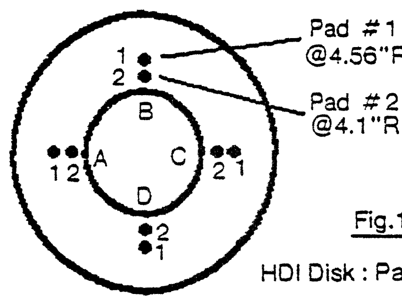



Fig.1

HDI Disk : Pad Layout

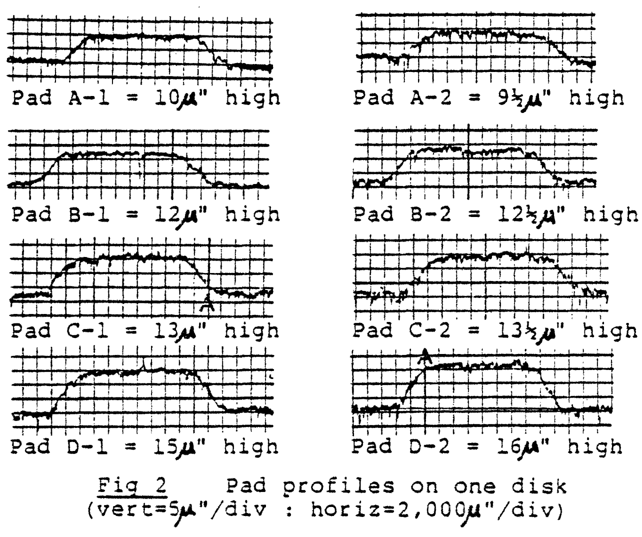



Fig 2 Pad profiles on one disk
(vert=$5\mu$"/div : horiz=2,000$\mu$"/div)

setting limits on acceptable HDI protrusions. The objective was to create several pads of controlled diameters and heights at the same radius so that when the HDI head flies over them, the output signals can be used to set thresholds. In this way, a standardized test criteria can be established among different companies so that the initial calibration can be set with an accuracy of about $\pm 1\mu$". It was found that the HDI head need not contact the pads to provide useful output signals.

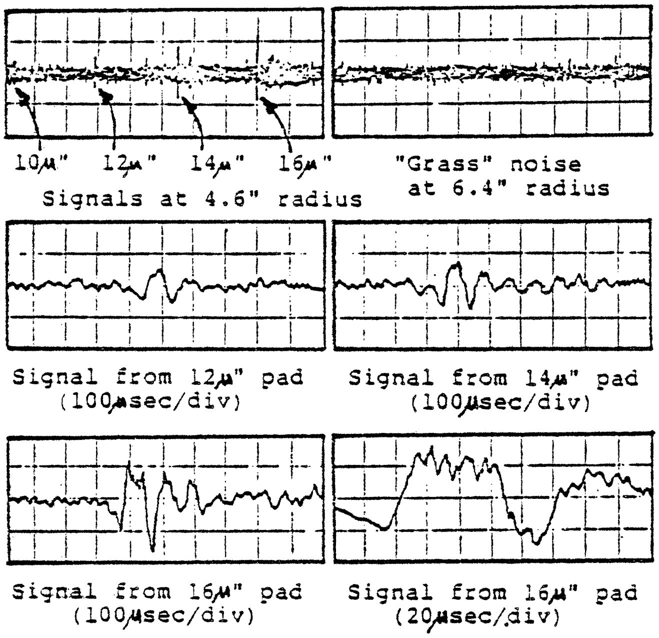



Fig 3 Signals from HDI disk at 1800 RPM

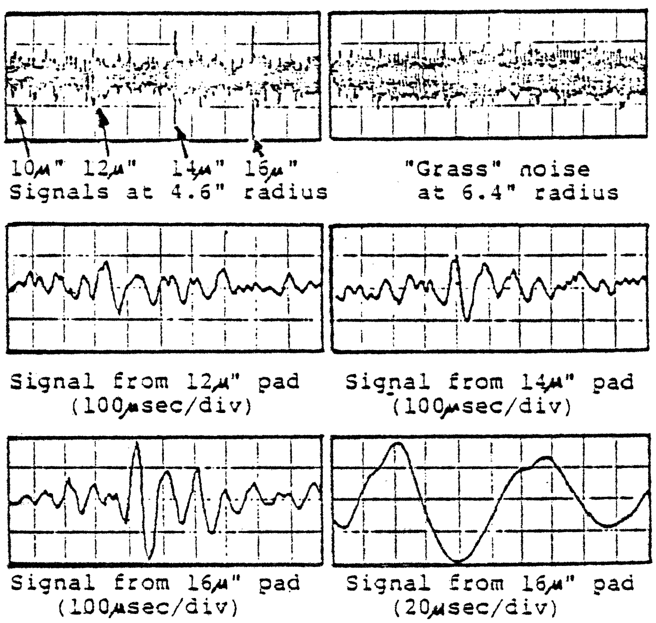



Fig 4 Signals from HDI disk at 3600 RPM

Figures 3 and 4 show photographs of HDI signals from pads of 10, 12, 14 and $16\mu$" in height (all with a diameter of ~0.02") at both 1800 RPM and 3600 RPM, with a $15\mu$" flying height. These pads were located at 4.6" radius. The "grass" noise is also shown at the 6.4" radius. Note that the reproduction of the photographs at the slower sweep rate may not show the peak amplitude. The true amplitude is shown more clearly at the $100\mu$sec/div sweep rates.

The pads of 12, 14 and $16\mu$" gave discernible signals with the head flying at $15\mu$", and even at $21\mu$". The $10\mu$" pad signal was not discernible because the "grass" noise level was too high. In order to discriminate $10\mu$" pads, the disk finish or profile must be improved - indeed, this would be most advisable anyway for increased accuracy in threshold setting.

Figure 5 shows the curves for the HDI head output voltage and signal to noise ratio (S/N) with the disk rotating at 1800, 2400, and 3600 RPM. Although the output voltage from the head contacting the deposited pads is greatest at the higher RPM, the "grass" noise level is also much higher. The net effect is that for a given HDI head, the best S/N is obtained at a lower RPM. If the RPM is too low, however, the S/N suffers because the "grass" noise increases substantially as the flying height decreases. Thus, for a given HDI head, there will be an optimum RPM for maximum S/N.

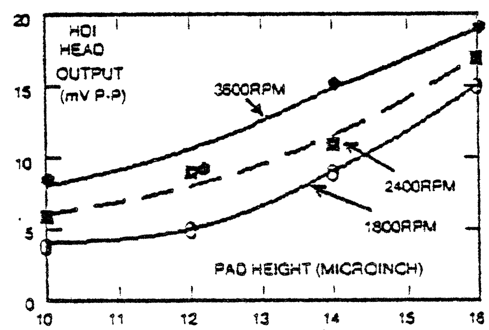
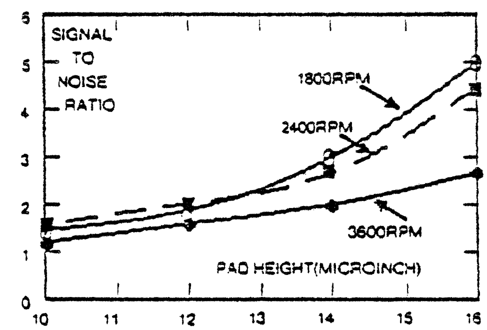



Fig. 5 HDI head output and signal-to-noise ratio v pad height and RPM




Figures 6, 7 and 8 show photographs of HDI signals at a constant velocity with load force, hence flying height, as a variable. As expected, the "grass" noise level is greatest when the head is closest to the disk surface. In contrast to the photographs of figs. 3 and 4, one can see that the "grass" level is much greater at the inner radius.

The first photograph in each set also shows that when there is actual interference between the pad and head, the head has a tendency to bounce along the disk after passing the pad. This may cause some burnishing of the disk leading to a possible head crash later, and should therefore be avoided if possible.

Figure 9 shows the signal amplitude and S/N for the same conditions. It is possible that if the load had been constant and the head pad width varied to change the flying height ( which is a better, but more difficult, approach), the HDI signal may have been greater at the lower flying heights, due to a difference in flying characteristics.

The photographs and curves show that there is an optimum condition for HDI measurements, the critical parameters being pad height, flying height, load force, and disk RPM.

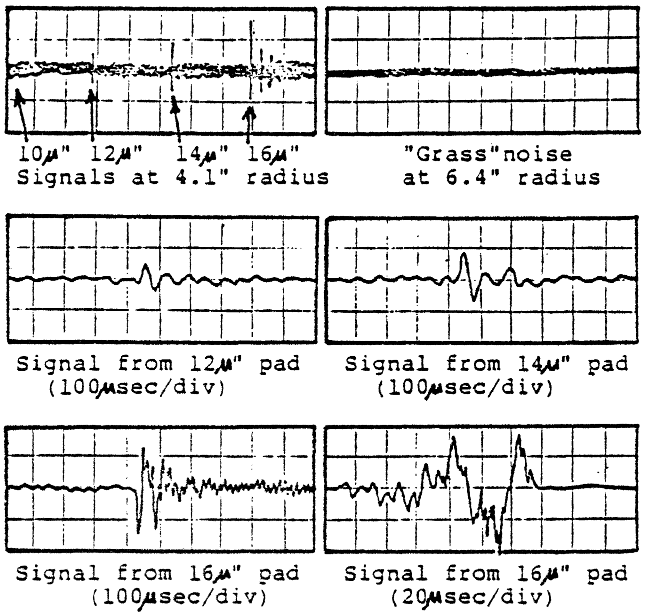



Fig 6 HDI signals with 225 grams load at 1800 RPM

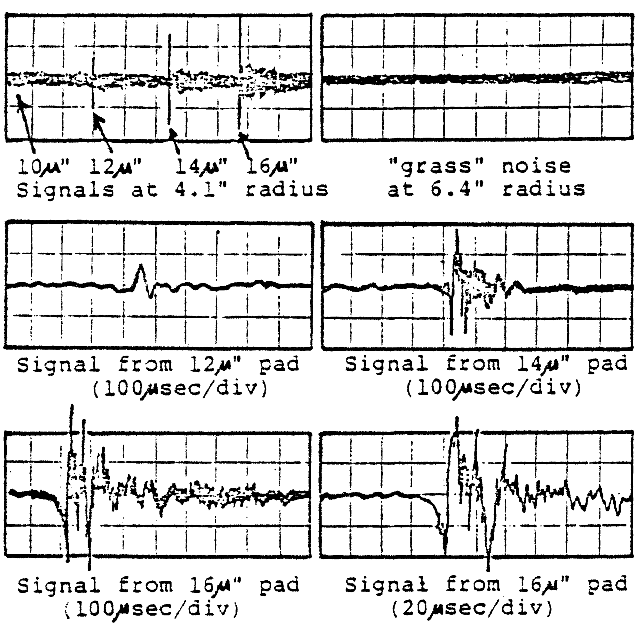



Fig 7 HDI signals with 277 grams load at 1800 RPM

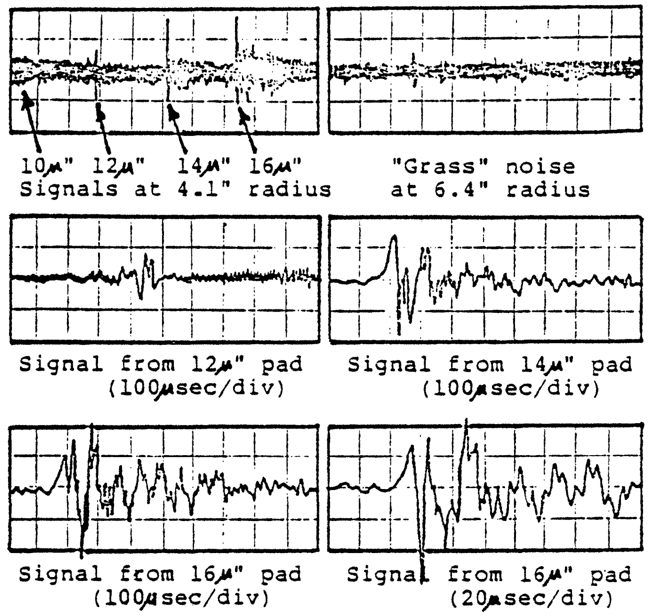



Fig 8 HDI signals from head with 330 grams load, at 1800 RPM

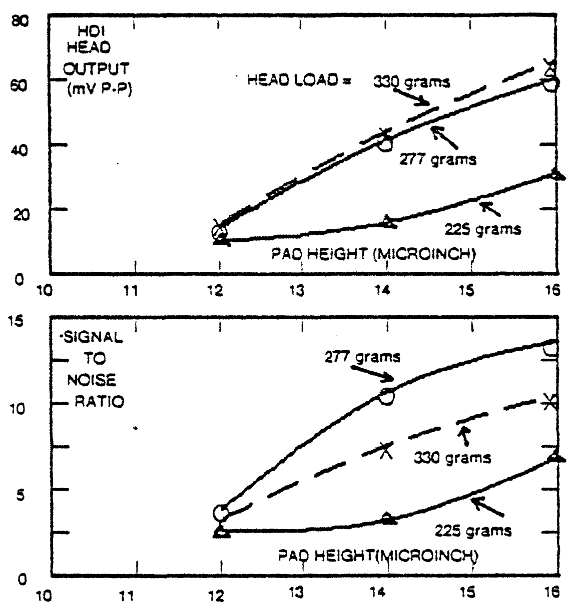



Fig. 9 HDI head output and signal-to-noise ratio v pad height and head load

## CONCLUSION

The HDI signals indicate that it is possible to set the signal threshold to discriminate pads with 1µ" difference in height, by standardizing on the pad diameters and by depositing pads with heights increasing in 1µ" increments. The use of such calibrated HDI disks can lead to a standard procedure which will allow one to get repeatable, correlatable results. By flying the HDI head at a flying height as low as 2µ" below the highest pad, the life of the HDI disks with tungsten pads will be more than 50 hours. If the HDI head flies at a flying height equal to the highest pad, there will be no pad wear and life of the HDI disk will be indefinite.