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Lab: Storage Lab 14
Duration – **1 week**
Completed on: **8/7/2005**

AN IN-DEPTH LOOK AT COMPACT DISCS AS A FORM OF OPTICAL STORAGE

OBJECTIVE:

The objective of this lab was to perform an in-depth examination of Compact Discs as a form of optical storage. The lab included an examination of SEM photographs of various CDs, as well as an examination of a CD drive used to read/write the data to the disk. The lab specifically set out to answer the following questions:

- How does the spindle motor of a CD drive compare to that of a FDD and HDD?
- How does the mass of the read/write head of a CD drive compare to that of a FDD or HDD?
- How does the performance of the CD drive compare to FDD and HDD in terms of the following parameters: Areal density, Access time, and RPMs?
- Based on the SEM images provided, what are the dimensions of the smallest pit?
- What are the track width and track pitch?

EQUIPMENT/SOFTWARE USED:

Hardware:

- Sony CD-R Drive Model No. CDU926S
- Sony Digital Camera Model No. DSC-P32

Software:

- Windows XP Professional
- Photoshop

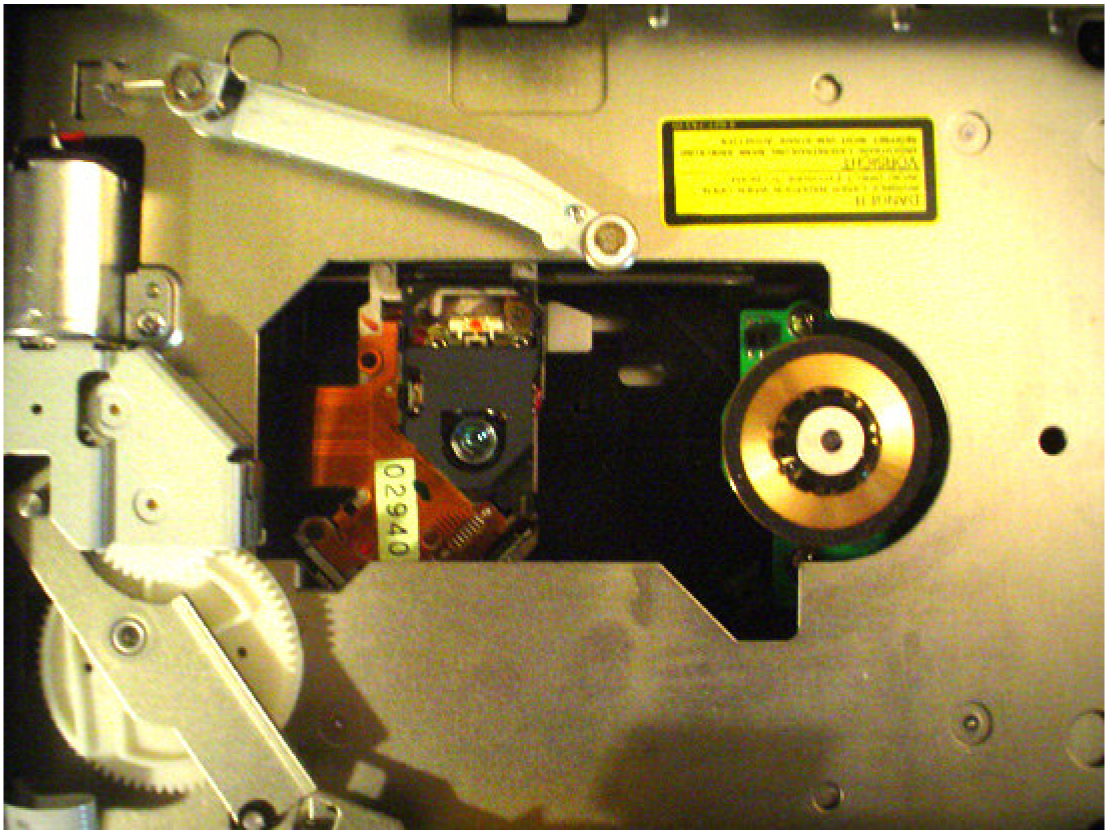
PROCEDURES:

One of the primary purposes of this lab was to physically inspect a CD-R drive and compare it to the inner workings of both an FDD and HDD. Thus the first step was to obtain and disassemble a CD-R drive. The drive used in this lab was a used Sony CD-R drive that was already in the position of the student. An image of the drive is shown below.

Figure 1 – Sony CD-R CDU926S

The outer case was removed from the drive, exposing the IC Board. The IC board and attached cabling was then removed, to show the R/W head and the spindle of the drive. An image is shown below.

Figure 2 – Sony CD-R R/W Head and Spindle



The head of the CD-R drive is noticeably larger than the head of an FDD or HDD in both physical size and mass. This is due to the fact that the CD-R head must hold the laser and related equipment in order to read from or write to the media. It should also be noted that movement of the FDD head and CD-R head is similar in the fact that it is driven laterally in one direction, while the disk spins. The HDD is similar, but the arm functions more like the arm of a record player. Also, a stepper motor is used in both the CD-R and FDD, while a linear motor or voice coil is used in the HDD. The following table provides a summary of a performance comparison. The performance comparison includes RPM (revolutions per minute), access time, and relative or approximate areal density. Comparing the RPM for each drive is interesting due to the fact that it demonstrates how finely-tuned the devices must be in order to handle an object that physically moves at such a high linear velocity. The access time is important to consider for practical purposes of understanding how quickly data is accessed on each drive. The areal density is also valuable to understand because it demonstrates how much data can be stored on that particular media with the current technology.

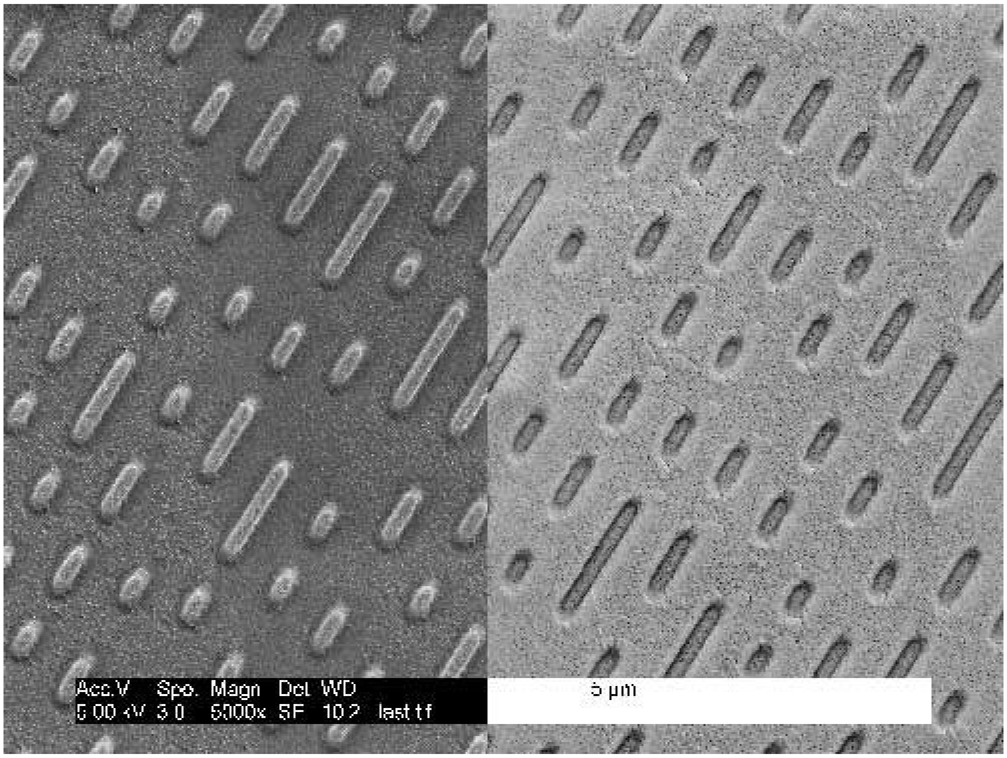
Table 1 – Comparison: CD-R, HDD, and FDD

	CD	**HDD**	**FDD**
RPMs	22,000	7,200	300
Average seek time (ms)	240-440	12	200
Areal Denstiy (Mb/mm^2)	0.75	77.5	.0178

The next portion of this lab is intended to provide further knowledge of the CD media. Several SEM pictures were provided for use in this lab. Due to the size of the images, they are not provided in full size in this document, however, certain scaled-down portions of those images are provided.

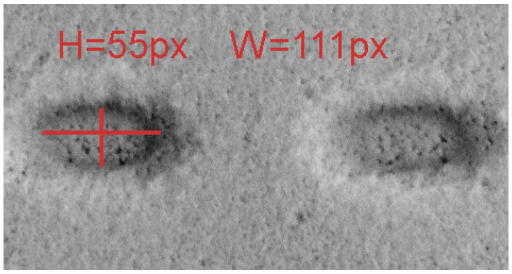
The first task was to examine one of the SEM photos to determine the dimensions of the smallest pit size. For the purposes of this lab, a “pit” will be defined as one of the areas in the SEM photo that appear to be protruding out from the surface. Since this seems somewhat counterintuitive, Adobe Photoshop was used to invert the original image, giving the “pits” better definition in the sense of them being concave. A portion of the original photo, as well as a portion of the inverted photo is shown below.

Figure 3 – SEM Photo of stamped media (half inverted)



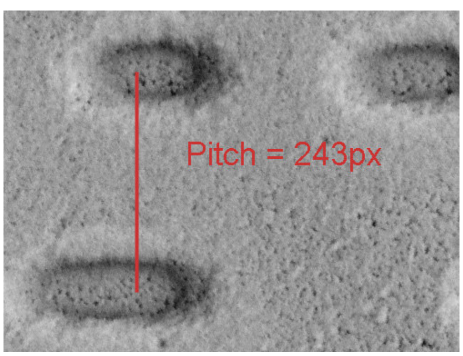
In order to determine the pit size, a higher resolution portion of the image was compared with the scale along the bottom of the image. Once imported into Photoshop, the 5 micron bar was exactly 781 pixels in length. Therefore, in order to determine the dimensions of the smallest pit, the image was rotated so that the pits were aligned straight in an x-y plane. The dimensions were then measured in pixels, and converted into micrometers based on the scale 5 microns = 781 pixels. The width of the pit was 111 pixels and the height was measured to be 55 pixels. Thus the physical dimensions are approximately: Width = 111px*5microns/781px = 0.71 microns; Height = 55px*5microns/781px = 0.35 microns. The results are shown below.

Figure 4 – Dimensions of smallest pit



The next task was to determine the track width and track pitch. If the track width is defined to be the width of a pit on the track, then from the previous measurements we know that the track width is approximately 0.35 microns. If the track pitch is defined to be the distance from the center of one track, to the center of the next track, then using the same technique as previously, the track pitch was measured to be: Pitch = 243px*5microns/781px = 1.6 microns.

Figure 5 – Pitch



Based on the information found in the course textbook (pp 172-173), a segment of the data is shown below translated to 1s and 0s.

Figure 6 – Translated Track Segment

REPORT:

Each of the procedures outlined in this lab were completed successfully. A Sony CD-R drive was dismantled and examined. In particular, the spindle motor and R/W head were compared to those found in FDD and HDD equipment. The head of a CD-R is noticeably larger than those in FDD and HDD due to the mass of the laser and related equipment.

Several SEM photographs were examined and used to make some basic calculations relating to CD technology. The smallest pit of a stamped CD was found to be approximately .71 microns wide and .35 microns in height. The pitch was measured to be approximately 1.6 microns. Lastly, a segment of the track was decoded and the results are provided in the procedures portion of the write-up.

CONCLUSIONS:

This lab was completed successfully and each of the objectives was met. Each of the questions outlined in the objectives were answered and the related results can be found in the procedures section of this document. Examining the inner workings of the CD-R drive was not a new experience for the student, however, with the newly acquired knowledge of CD technology, the precision and complexity of the system was much more appreciated than previous times dismantling similar equipment. It was also very interesting to see the SEM photos of the CD media. The accuracy with which such small pits are duplicated is quite amazing.

Looking to the future, it might be somewhat difficult to improve upon current CD technology, while still remaining backward-compatible. The media itself could be improved by increasing the areal density of the data on the medium. With more finely tuned R/W technology, a higher density is quite feasible. However, changing the density of the disk would ultimately require users to upgrade hardware in order to read the new media. In fact, this is essentially what has happened to create DVDs. A DVD and CD are both very similar forms of optical storage, but their differences are such that they require different hardware to read a DVD than to read a CD (although DVD drives are typically able to also process CD media). Because changing the media itself may not be a feasible way to improve upon the technology, the focus of improvement must then be in the drive itself, and its ability to read from the media. By increasing the speed of the motor, and improving upon related technology with speed, then higher data transfer rates could be obtained. However, when spinning at such high speeds, the complexity of the reading technology increases substantially, due to environmental factors such as physical alteration in the media, wobbling, vibration, etc.

Overall, this lab can be considered a success. A deeper appreciation and understanding of optical storage was obtained. This lab offered the opportunity to see how far technology has come in being able to create amazing devices for storing abstract data.