

CINE-GT 2920 Final Project
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MiniDisc **A technology that could do no wrong**

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1. Introduction

2019 marks the 40th anniversary of Sony's flagship invention - Walkman. "Walkman", a registered trademark of Sony and later a generic term, implies a series of consumer-oriented portable media players. Sony released a 1-minute house advertisement that features signature Walkmans, namely cassette Walkman, CD Walkman, MiniDisc Walkman, and MP3 Walkman¹. While most of these media formats enjoy approximately 20 years life in the market, MiniDisc is an exception. In 2013, inventor of MiniDisc— Sony discontinued manufacturing of MiniDisc players, marking an end to the series.

Despite the fact that MiniDisc was promoted as a flagship product that greatly excelled Sony's another milestone invention – Compact Disc (CD), MiniDisc is later regarded a format that failed². Nevertheless, it is not difficult to find commentaries that applauded to this technology, especially back in the 1990s - Sony at its height in international market expansion. It was regarded a technology that features "editing at your fingertips"³. Media reviewer once wrote, "in 1992, when the quirky new music format was introduced, Sony could do no wrong in

¹ "Walkman@ 40th Anniversary Movie," Sony, accessed June 30, 2019, https://www.youtube.com/watch?v=YH2T94XWqck&feature=youtu.be&fbclid=IwAR2C3oFmKb8xNKuCNsat_j8110fq1SdIxmz2mrR2qZz0G3b_Q_rJS0D11W4.

² Jeff Parsons, "MiniDisc: The format that failed: Last Sony MiniDisc players will ship in March," *T3*, Feb 1, 2013, <https://www.t3.com/news/minidisc-the-format-that-failed>.

³ Ken Henderson, "A rebirth in digital recording," *IEE Review*, 1999: 13-16.

consumer electronics.”⁴MiniDisc was an industrial advancement that, as Sony promised, was armed with the CD-quality and cassette convenience⁵.

In this paper, I am going to discuss the technical specifications, manufacturing features, recording-playback devices, reasons of obsolescence, and preservation issues.

Now, MiniDisc is a generic term that includes a number of different formats. But in this paper, I will focus on recordable audio MiniDiscs specifically for consumer market.

2. Birth of MiniDisc

MiniDisc was branded as a Sony revolutionary product in early 1990s. Before going into discussion on MiniDisc, a brief introduction of Sony – the pioneer of portable audiovisual devices - is necessary. In 1946, when Japan rebuilt from ashes of World War II, Tokyo Telecommunications Engineering Corporation, the predecessor of Sony was established by Masaru Ibuka. In 1955, Sony produced Japan’s first consumer-oriented pocket-size transistor radio, greatly changing general consumers’ sonic experience. Since then, Sony keeps introducing innovative audiovisual products for both industrial and consumer markets⁶.

Research and development of MiniDisc technology began in 1986. Sony announced its MiniDisc format in 1991, with product launch a year later in 1992 (Figure 1). The introduction of MiniDisc aimed at rivaling another audio media Digital Compact Cassette (DCC) which was launched by Philips from Germany⁷. The onset of the 1990s also marked the decade of conversion from analog-based to digital audio in the sound industry. And Sony, as a pioneer in sound technology in the world, predicted that “all analog audio is being supplemented by digital

⁴Nilay Patel, “Status Symbols: MiniDisc,” *The Verge*, Feb 15, 2013, <https://www.theverge.com/2013/2/15/3989872/status-symbols-sony-minidisc>.

⁵Joey Faulkner, “MiniDisc, the Forgotten Media,” *The Guardian*, Sep 24, 2012, <https://www.theguardian.com/music/musicblog/2012/sep/24/sony-minidisc-20-years>.

⁶“Corporate History,” Sony, accessed Nov 6, 2019, <https://www.sony.net/SonyInfo/CorporateInfo/History/>.

⁷Interestingly, we can see advertisements of MiniDisc and DCC were placed side by side in the same issue of *Billboard* in 1993. See “This is it,” *Billboard*, Mar 13, 1993, 92-93. “How Many ‘Firsts’ Can You Expect From Your Suppliers of DCC Cassettes?” *Billboard*, Mar 13, 1993, 95.

audio”⁸. Under this umbrella, MiniDisc was designed to be the first recordable, erasable optical disc of digital audio format for consumer market⁹.

Figure 1. MiniDisc logotype created by Sony¹⁰



Sony underlined two features of MiniDisc. First, MiniDisc allows consumers to record and overwrite on high-quality but affordable optical discs¹¹. At that time, if home users wanted to record their own music albums, they mostly relied on magnetic tapes. Second, MiniDisc was regarded the successor yet more superior candidate than CD. Both MiniDisc and CD are optical media. MiniDisc showed similarly high-quality sound recording as CD did, while MiniDisc was much smaller and more durable than CD. The introduction of MiniDisc also exhibited Sony’s intention to replace cassette tapes and CDs with MiniDisc in worldwide consumer market¹².

There existed a book documenting basic specification of MiniDisc – the Rainbow Book. The naming of this book was consistent with a series of other technological guidebooks that were co-developed by Sony and Philips¹³. Sensing that consumers were eager to see high-quality sound recording media in a portable size, Sony and Philips jointly developed different types of CDs in the late 1980s. In order to set an industrial standard, these two companies co-introduced

⁸Jan Maes, *The Minidisc* (Oxford: Focal Press, 1996), 1.

⁹Ken C. Pohlman, *Principles of Digital Audio*, 5th ed. (New York, Chicago and San Francisco: McGraw-Hill, 1995), 418.

¹⁰“Sony Design,” Sony, accessed Nov 6, 2019, <https://www.sony.net/Fun/design/history/product/1990/minidisk.html>.

¹¹The first MiniDisc was actually a non-recordable one. But very soon, Sony flooded the consumer market with recordable MiniDiscs. See Maes, 23.

¹²Tadao Yoshida, “The Rewritable MiniDisc System,” *IEEE* 82 (1994), 1492.

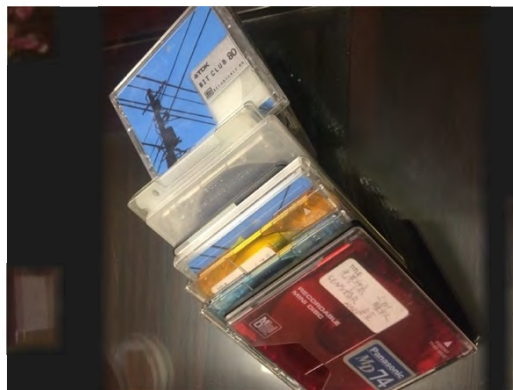
¹³These “books”, co-developed by Sony and Philips - two sound technology leaders, outline the basic parameters and specifications for each media, in order to standardize the formats for international manufacturers and markets.

the “books”. The Red Book was about CD, the Yellow Book for CD-ROM (Read Only Memory) and the Orange Book for CD-MO/WO (Magneto-Optical disc and Write Once disc). Sony followed this naming system, but giving a more sensational name - the Rainbow Book, indicating MiniDisc embraced all technological advantages of predecessors¹⁴.

3. Technical Specification of MiniDisc

From the appearance, a MiniDisc looks like a mini-size CD embedded in a plastic cartridge. The cartridge is mainly for protection of the disc. The disc is made out of polymer materials with a mirror-like reflective metallic surface. The whole cartridge is around palm size, light weighted. There is a metal shutter at one side of the cartridge. By default, the shutter is closed to protect the disc. Similar to many recordable media with cartridge protection (e.g. VHS), there is a tiny switch – write protector - on MiniDisc cartridge (figures 2&3).

Figure 2. My partial collection of recordable MiniDiscs



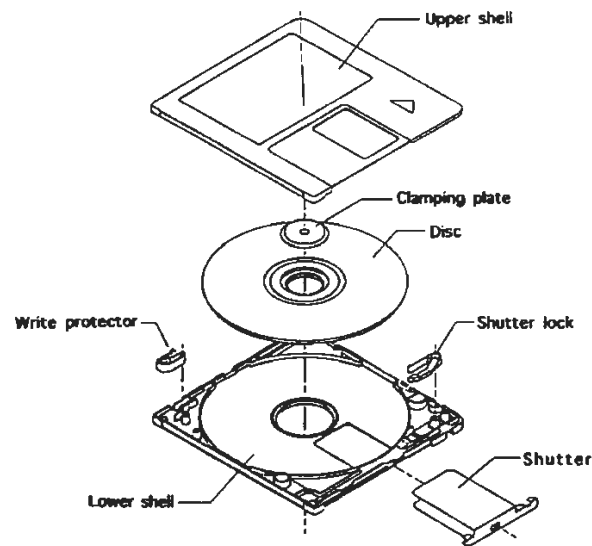
Below are physical specifications of MiniDisc:

- Playing and recording time of disc: 60, 74 or 80 minutes
- Diameter of the disc: 64mm
- Thickness of the disc: 1.2mm
- Diameter of center hole: 11mm

¹⁴Maes, 3-5.

- Clamping area¹⁵: 16.4mm
- Starting diameter of lead-in area: 29mm max
- Outer diameter of lead-in area: 32mm (similar to CD, recording on MiniDisc starts from the inner to the outer area)
- Track pitch: 1.6 μ m
- Size of cartridge: 72 X 68 X 5mm
- Weight: 30g (including disc)

Figure 3. Cartridge exploded view¹⁶



4. Recording and Playback Mechanisms of MiniDisc

MiniDisc stores data in a digital form (0 or 1) and it is through an analog (A)/digital (D) conversion mechanism that data is interchangeable. There are usually two types of MiniDisc for the consumer market – premaster and recordable. Here I will focus on the latter type.

4.1 Premaster MiniDisc

¹⁵A center clamp that hold and stabilize the disc at a precise position for laser readout and recording.

¹⁶Yoshida, 1495.

Before studying into recordable disc, knowing the general mechanisms of premaster MiniDisc/CD is useful. In terms of a premaster MiniDisc, the recording and playback mechanisms are as the same as those of a premaster CD: analog data is A/D converted, encoded (control data is added to allow CD players recognize) and modulated (for error correction). These processed data will be recorded on a spiral track, starting from inner to outer side of the disc. The digitized data of either 1 or 0 will be reflected on the disc through pits (figure 4), which are made from mother plates stamping on them¹⁷. The other side of the pits are bumps, which are later read out by laser beams projected from the side that touches disc's polymer substrate. To read out the data, a laser light from the optical pickup will be projected onto the pits and subsequently different weights of reflective lights will be generated. The reflective lights then will be demodulated, decoded and D/A converted back to analog data – audible sounds.

Figure 4. Pits that represent digital data on premaster discs¹⁸



As mentioned, the naming of Rainbow Book was because MiniDisc was touted embracing all advantages of different media in other monochromatic books. While the appearance and encoding-decoding methods of MiniDisc are similar to those of CD, the recording-playback

¹⁷To make mother plates, metal masters were produced first. Metal masters store data in laser beam generated pits. The “shape” of the metal master, including how the pits are cut and aligned, is engraved to make mother plates. These mother plates then are used to stamp hundreds of thousands of consumer-use discs, producing the same “shape” of pits. The signal surface of each disc is then coated with a reflective material to enable optical readout. See Luc Baert et al., *Digital Audio and Compact Disc Technology*, 3rd ed. (Oxford, Focus Press, 1995), 113-115.

¹⁸Yoshida, 1494.

system is actually similar to CD-MO/WO¹⁹. But what makes MiniDisc different from CD-MO/WO is a secret weapon called ATRAC.

4.2 Magneto-optical recording of MiniDisc

MiniDisc requires both optical and magnetic heads to perform recording and MiniDisc is embedded with more data processing systems than CD to optimize data recording and playback.

First, in the MiniDisc system, a magnetic-field modulation is introduced as a safer method to store data and a more advanced feature which allows re-writable recording. Different from the optical-field modulation in making premaster discs, the magnetic-field modulation here does not use pit but magnetic information to store data under the assistance of optical force.

The mechanism is based on a physical law which relates to the Curie temperature. Many metals can be magnetically influenced by magnetic fields once their temperature hits certain points – the Curie temperature (Curie point), because at that certain temperature, the metal itself will become a magnetic metal. Now, let's imagine the MiniDisc recording process in a slow motion: When conducting recording, laser beam will be used from one side to heat the metal up to its Curie temperature – at this temperature, the metal is magnetic. Meanwhile, the magnetic head at the other side will write data on the disc – the turned magnetic metal. Here, North or South pole equals 1 or 0 in the digital realm. (Figure 5). When conducting re-recording, new data will be directly written on old ones²⁰.

This mechanism is similar to that of magnetic tapes, but the creation of magnetic data on MiniDiscs under a high temperature environment. And such high temperature is beyond the scope of daily human activity. Therefore, the data stored under this magneto-optical system is more secured than those written on traditional magnetic tapes (e.g. cassette tapes). Generally

¹⁹Maes, 9-10.

²⁰Maes, 37-39; Yoshida, 1495.

speaking, such recording process theoretically allows endless times of overwriting and re-recording, as long as the metal layer is heated up to the required point.

Sony uses a material called ferri-cobalt-terbium (FeTbCo) as their magneto-optical layer (Figure 6). It is a type of metal with a relatively low Curie point (185°C) and low coercivity that could most efficiently make such magneto-optical recording happen²¹.

Figure 5. Magnetic-field modulation recording and overwriting system²²

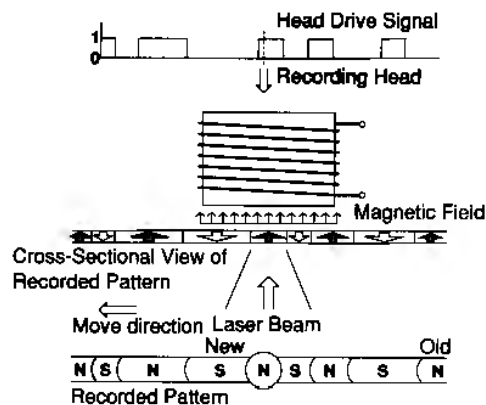


Figure 6. MiniDisc cross-section²³

Lubricant
Protective layer
Reflective layer
Dielectric layer
Magneto Optical layer (TbFeCo)
Dielectric layer
Polycarbonate substrate

4.3 Readout of MiniDisc

²¹This means a relatively low magnetic field could write data on the disc.

²²Yoshida, 1496.

²³Modified by the author based on Luc Baert et al., 239.

The readout of premaster MiniDisc is as the same as that of CD. But the readout of recordable MiniDisc shows a different mechanism, which, as the previous section indicated, involves the role of magnetic field.

Readout of the data requires laser beams projected from the laser head. Laser light would hit the disc surface, pass through the magneto-optical layer and hit the reflective layer – the magnetically written data. To retrieve the magnetic data, the reflected light beam will go through a Wollaston prism – two bonded rock crystals. This type of prism gives out different outputs when receiving light beams reflected back from different magnetic poles. As mentioned, on the disc, magnetic data of North or South is written to represent 1 or 0. After the light beam goes through the magneto-optical layer and is reflected back to the Wollaston prism, the prism will send out main beam and side beams. A light beam reflected from different magnetic poles will have different shapes and angles of side beams, so that the readout of data is made possible²⁴.

4.4 ATRAC data compression

In the early 1990s, Sony launched MiniDisc as a defining technology that could excel CD in terms of audio performance. MiniDisc was therefore embedded with a number of features that were at more advanced level than those of CD, namely the advanced cross interleave reed/Solomon correction (ACIRC) encoder-decoder system, the address in pre-groove (ADIP) system which allows users to embed new address information when conducting recording, shock resistance memory that gave stable acoustic experience to users, and the signature ATRAC data compression mechanism.

ATRAC, short for adaptive transform acoustic coding, is the secret that allows MiniDisc to store the same size of data on its 64mm-diameter disc which is much smaller than CD (120mm-diameter).

²⁴The angle of the side beams is called Kerr angle. Luc Baert et al., 240-242.

The theory behind the operation of ATRAC is human's perception of sound – psychoacoustics. First, as the sensitivity of our hearing system is not linear over the theoretically audible range of 20Hz and 20kHz, certain frequency of sounds is actually less perceivable than others. Sound at a minimum level of perceivable is regarded as at the threshold of hearing. That is to say, sounds below this threshold become less useful and thus could be omitted. Another mechanism is called masking. When audible sound at a lower frequency is covered/masked by a higher frequency sound, the former one actually becomes inaudible. By analysing each frequency of sound at a given moment, we could delete those frequencies that are masked. The third mechanism is related to critical bands. It is said that human's hearing is more sensitive in certain areas than in others. In critical bands, signals appear not to be separated. If a system can analyse the composing frequencies of a sound, it can reduce the redundant data²⁵. It is based on these psycho-acoustic mechanisms that ATRAC is developed. By mathematically analysed the input audio, the system can define, split, and transform the data into a smaller size for storage²⁶.

To note that, after such process, the result of ATRAC encoding data is no longer described as audio data. Instead, this becomes a type of data that describes parts of the audio spectrum in word lengths and scale factors. During readout, this ATRAC encoded data will first go through EFM²⁷ and ACIRC before reaching to ATRAC for decoding (figure 7).

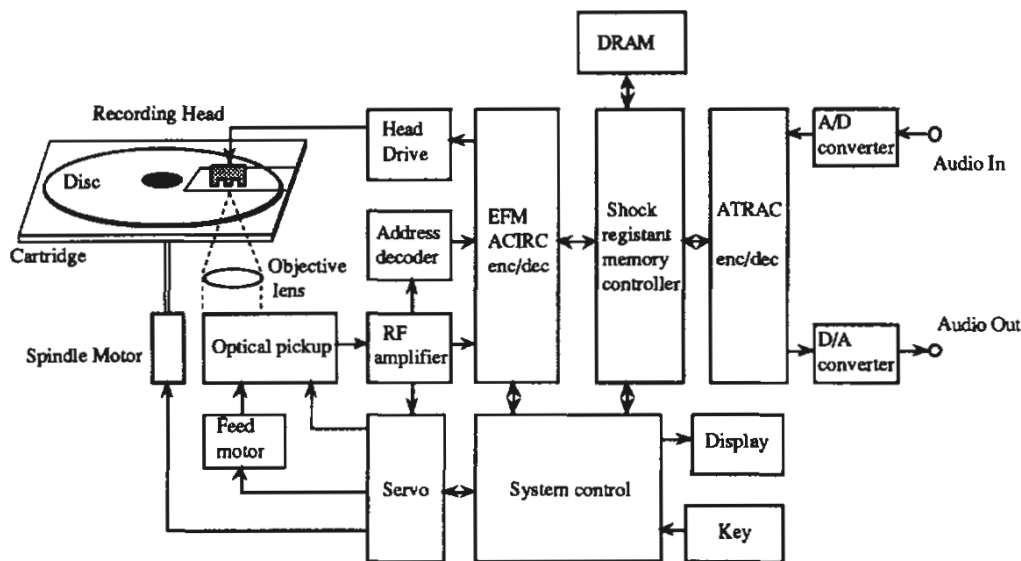
Figure 7. Full block diagram of MiniDisc²⁸

²⁵Maes, 61-63.

²⁶Maes, 65.

²⁷A data compression and correction mechanism used in CD and MiniDisc systems. The term is short for eight-to-fourteen modulation.

²⁸MaedaYasuaki, "Minidisc System," *IEEE 1993 International Conference on Consumer Electronics Digest of Technical Papers* (1993), 124-125.



5. Patenting MiniDisc Technology

Since the early 1990s, Sony was greatly ambitious to launch MiniDisc to the market by highlighting a series of technological advantages of this 64mm cartridge-held optical disc. Thanks to a web-based community of MiniDisc lovers, a list of patents is integrated by MiniDisc researcher Eric Woudenberg (<http://www.minidisc.org/patents/>). While some of them were filed by companies from South Korea or the US, most of the patents were obtained by Sony²⁹.

The first patent application for MiniDisc conducted by Sony was dated back to 1991, stating that “the inner diameter of a data recording region of the disc-shaped recording medium is in the range from 28 mm to 50 mm.”³⁰ Soon after, a more comprehensive patent of MiniDisc was

²⁹Some patents shown on the list are related to data compression technologies, indirectly related to MiniDisc.

³⁰Katsuaki Tsurushima and Tadao Yoshida, Disc-shaped recording medium, US patent 5,244,705, filed Aug 19, 1991, and issued Sept 14, 1993. Full patent file could be retrieved from <http://www.minidisc.org/patents/pdfs/US05244705.pdf>

filed in 1993, in which a detailed illustration of the block diagram, ATRAC, magneto-optical mechanism and other MiniDisc features were documented³¹.

As mentioned, ATRAC makes a signature of MiniDisc. In 1993, Sony filed a patent registration for this technology, articulating how sound features are decomposed for further compression process, “The number of spectrum-dependent quantizing bits allocated to each band by the adaptive bit allocation circuit is determined according to the band magnitude, weighted depending on the band frequency.”³²In the following years, Sony continuously registered patents for improved versions of ATRAC. By 1997, the third generation already existed.

In addition to the above, there are patents of mastering MiniDisc, the magneto-optical system, magnetic and optical heads, and versatile functions on different MiniDisc players.

6. Non-Asian Market of MiniDisc

In the battle with Philip’s DCC format, MiniDisc in the mid-1990s already gained much larger market-share than DCC thanks to Sony’s proactive global marketing³³. Sony actively promoted this music format to global markets, especially Europe and North America. At the outset of MiniDisc launch, Sony touted they shipped a few million plays overseas. In 1992, Sony claimed that they sold 50,000 MiniDisc units in the U.S. Also, there were 1200 pre-recorded MiniDisc titles coming out, of which about 450 were offered by record companies independent of Sony³⁴. That being said, according to Billboard, it was in 1996 that Sony published their first

³¹Tadao Yoshida, Disk recording/reproducing apparatus and disks applied therein, US patent 5,552,896, filed Nov. 18, 1993, and issued Sept. 3, 1996. Full patent file could be retrieved from <http://www.minidisc.org/patents/pdfs/US0552896.pdf>

³²Kyoya Tsutsui and Kenzo Akagiri, Apparatus and method for data compression using signal-weighted quantizing bit allocation, US patent 5,301,205, filed Jan 29, 1993, and issued Apr 5, 1994. Full patent file could be retrieved from <http://www.minidisc.org/patents/pdfs/US05301205.pdf>

³³Henderson, 13.

³⁴Ratazzi, 12-13.

global advertisement of MiniDisc. This commercial was aired on MTV and US Networks, aiming at promoting this media format to Europe, Asia and Latin America³⁵.

MiniDisc as a media format was actually more popular in Europe (especially in UK) than in North America. For example, BBC in 1998-1999 created a huge oral history project called “Millennium Memory Bank” which used MiniDisc as their major storage media. The project is now part of the British Library Sound Archive³⁶. However, in North America, MiniDisc was only popular among professional or tech-geeky communities³⁷.

7. MiniDisc Recording and Playback Devices

There are different types of recording and playback devices for professional and consumer markets: portable player, portable recorder-player, decks, bookshelf, boombox, CD/MD deck, automobile deck, professional deck, professional multitrack, and data device (MiniDisc used for camera data storage).

To many MiniDisc users, the most familiar type is the portable devices. And Sony, as the leader in the field, dominated the device market. The first Sony MiniDisc recorder-player was MZ1 which was released in 1992. It was a portable size with an LCD display on the surface. This first gadget was already equipped with almost all the features of MiniDisc technology: ATRAC, shock-resistance memory, track searching and shuffling function, and most importantly, the magneto-optical recording system. Very soon, in 1993, a second generation of ATRAC was already launched in Sony’s second portable MiniDisc recorder-player MZ-R2, and the third generation in 1995. Starting from the MZ-R2, a stick controller was installed, bridging the earphone and the device. In every new type, Sony kept adding new functional buttons to their

³⁵ “Newline,” *Billboard*, Sept 21, 1996, 52.

³⁶ “Millennium Memory Bank,” British Library, accessed Nov 6, 2019, http://cadensa.bl.uk/uhtbin/cgiirsi/x/0/0/5?searchdata1=CKEY5258693&library=ALL&_ga=2.34071585.1282269765.1573051972-1680108785.1573051972.

³⁷ Paul Verna, “MiniDisc Still a Niche Format in U.S.,” *Billboard*, July 24, 1999, 85.

MiniDisc devices, making processes of recording, song selection, and song title input more versatile. This is also why Sony filed a large number of patent registrations.

Since the beginning of MiniDisc technology, Sony already licensed manufacturing of MiniDisc to other electronic companies. In a press release in Austria in 1992, then president of Sony announced 23 hardware companies, 8 software-related firms and 10 blank-tape manufacturers have signed licensing agreements³⁸. From here, again, we can see Sony's determination and enthusiasm. In 1993, besides Sony, there was already a Sharp-brand MiniDisc player in the market. In the heyday of MiniDisc (mid-1990s and early 2000s), there were more than ten manufacturers that produced MiniDisc recorder-players. From figure 2, you can see I, as a common user, owned MiniDiscs of different brands, such as TDK, Panasonic. Nevertheless, among them all, Sony was with no doubt the industrial leader³⁹.

In 2001, to catch up with the pace of personal computer development, Sony had to shift their focus on making MiniDisc compatible with the rising MP3 music format. As a result, Net MiniDisc (NetMD) player was introduced to consumer market⁴⁰. The first NetMD by Sony was MZ-N1, which allowed direct PC to MD download (but not upload) of compressed ATRAC sound data. A USB connection was added, and an exclusive software was developed for users to convert computer-based formats (e.g. MP3, WAV) to their MiniDisc devices. New backlit LCD displays were embedded on both the MiniDisc device and the stick controller, making the metallic-surfaced machine look even fancier. Chinese characters (*kanji*) were added to the system, which could be displayed on the LCD monitor. A seemingly attractive feature, the multi-

³⁸“Sony Details MD Launch at Euro Press Gathering,” *Billboard*, July 4, 1992, 47.

³⁹“Equipment Browser,” *minidisc.org*, accessed Nov 6, 2019, http://www.minidisc.org/equipment_browser.html

⁴⁰Paul Ratazzi, “MiniDisc: Successful Innovation or Just Cool Technology?,” (Report submitted to course DSES 6470, Rensselaer Polytechnic Institute, Troy, NY, 2004), 16.

language feature later proved a curse than blessing. In 2002, to mark the tenth anniversary of MiniDisc, Sony launched the model MZ-N10.

8. MiniDisc Recession and Obsolescence

If what has been extensively discussed is the advantages of MiniDisc, the contents below draw upon the downside of this technology which, due to a series of internal and external reasons, recessed from the market in 2013 and became an obsolete media.

8.1 *Reasons of obsolescence*

One of the reasons is from the organization itself – Sony. In the late 1980s and early 1990s, then president of the company Norio Ohga envisioned the arrival of an era of recordable media and he was confident that consumers already showed confidence on CD over magnetic cassette tapes. He decided to produce a CD-like media but in a more portable size. However, in fact in that period of time consumers were still fond of using cassette tape as their primary recording media and CD consumption was a relatively expensive one⁴¹. Such mis-judgement made by Sony already set an unsolid foundation for its supposedly flagship MiniDisc invention. What's more, in the similar time period, Sony's rival Philips launched the DCC as a counterpart to MiniDisc. The competition between these two gave rise to market confusion, similar to the situation of Betamax vs VHS⁴².

Price always comes as an apparent factor in the world of technology. The first Sony MiniDisc recorder-player costed \$750 – an astonishingly high price to general consumers even in today's society⁴³. Similarly, a black MiniDisc unit costed \$23.4⁴⁴. It is not difficult to imagine, such pricy appliance drove teenagers away, who preferred using the more affordable cassette

⁴¹Ratazzi, 5-6.

⁴²Wikipedia, s.v. "MiniDisc," last modified Sept 30, 2019, 17:56, <https://en.wikipedia.org/wiki/MiniDisc>.

⁴³Faulkner.

⁴⁴"Sony Details MD Launch at Euro Press Gathering," *Billboard*.

tapes. Even in 1998, 6 years after the launch of MiniDisc, even in the Japanese domestic market, 230 million cassette tapes were sold while the sales number of MiniDisc was 91 million units⁴⁵.

Another reason is the limited number of premaster MiniDisc in the market. Though one of the highlights of MiniDisc was allowing people to mix their own records, this is after all a time-consuming move to general users. With sufficient premaster discs in the market, consumers can save their time while simply enjoy finely produced music. It is difficult to trace in totally how many titles were released in MiniDisc. Some hints could be found from various sources. For example, in 1992, when Sony heralded this technological innovation to global market, there were already some global major record labels had little interest in making premaster MiniDisc titles, such as PolyGram which was fond of DCC⁴⁶. In a 1999 *Billboard* report, more information could be found. For many years, Sony was the only major record label that released premaster MiniDisc titles. Until 1999, they produced several hundred titles. Also in the late 1990s, EMI produced around 70 titles. However, other majors such as Universal Music Group, PolyGram still had little interest in MiniDisc in 1999, while Warner Music was considering⁴⁷. Another hint is, in a popular and extensive online discography community based in English countries, a list of 1769 titles of premaster MiniDisc is found⁴⁸. Among them, most of the titles were released in the late 1990s. Nevertheless, compared to the number of titles of premaster CD, this number was much less significant. On the same website, the number of titles on premaster CD released in 1999 is 68,399.

In addition, an important reason of MiniDisc's failing destiny was an external factor: the astonishingly rapid growth of personal computer users in the millennium years.

⁴⁵Steve McClure, "Japan: MiniDisc Tops Home Recording," *Billboard*, July 24, 1999, 84.

⁴⁶"Sony Details MD Launch at Euro Press Gathering," *Billboard*.

⁴⁷Dominic Pride, "MiniDisc Revival Brewing Abroad," *Billboard*, July 24, 1999, 84.

⁴⁸"MiniDisc," Discogs, accessed Nov 6, 2019, <https://www.discogs.com/sell/list?format=Minidisc>.

Subsequently, computer-derived music formats, such as MP3, WAV, FLAC, mushroomed. With a palm-size MP3 player, music lovers can simply transfer music from their computers to the devices without extra software installation and format conversion. What's more, iPod from Apple provided a yet fad too chill to be resisted. The first generation of iPod offered a capacity of 5GB which could store around 1000 songs – a capacity that significantly put MiniDisc under shadow.

Last but not least, I speak from my own experience as a MiniDisc user. I purchased Sony's MZ-N10 in Japan in 2003. Back then, this model was the latest one. Even though I was deeply attracted by its metallic body and different glittering controlling buttons, I soon found this gadget had serious drawbacks. Usage of the player could lead to nightmares. The versatile functions embedded in a large number of buttons often led me to a nebulous status. In term of language, on the one hand the system was compatible with Chinese characters. On the other hand, actually the so-called Chinese system was derived from its original Japanese configuration. As I neither had a Japanese-language computer environment nor understand Japanese, the information of songs I created through the MiniDisc software "SonicStage" often turned illegible. Software was another problem – user-unfriendliness and system exclusiveness. In online community minidisc.org, users' reviews tend to stand by my side. Literally speaking, without installing the particular software provided by Sony, users had no way to transfer data from computer to MiniDisc player. First Sony introduced Open MG Jukebox as the software for their first generation NetMD. It was until MZ-N10 that SonicStage replaced the Jukebox. Neither of them got positive review.

8.2 Obsolescence status and preservation

Sony announced manufacturing of MiniDisc players ended in 2013, bringing this media format into “official” obsolete status. While blank MiniDisc units are still found in the market, it is unclear whether MiniDisc production is still going on. Despite of these, a music lover blogger claimed Japanese company Teac is still producing MiniDisc player⁴⁹. From the official website of Teac, I can tell that Teac is still selling CD/MiniDisc deck, which, however, is for Japanese market only⁵⁰. According to Museum of Obsolete Media, MiniDisc is considered “vulnerable, or some risk” (level 2), same level as VHS and compact cassette. It means “The format is no longer current but may still be in use, and equipment capable of reading the media is still relatively common even if no longer produced.”⁵¹ In the same line with such statement, I find there are still online social-media platforms related to MiniDisc history, MiniDisc equipment and premaster titles. In these communities, MiniDisc still have a large group of fans who are still actively recording and listening to MiniDisc⁵². In 2018, there was a blog post by the British Library about “revival” of MiniDisc for releasing artworks⁵³. Therefore, it is important to preserve the MiniDisc media, related software and players, yet this is not yet an urgent need.

To preserve MiniDisc, storing discs at cool and dry place is necessary. Even though MiniDisc, as the optical disc is permanently embedded in a plastic cartridge, could be free from problems that are common to optical born-digital discs (e.g. dust, solvent, labels, fingerprints), other external factors could still damage the stored data. For example, under long-term direct sunlight, the plastic cartridge could become brittle, chipping and thus its protective function is

⁴⁹Brian Ashcraft, “Japan Hasn’t Given Up on the MiniDisc Just Yet,” *Kotaku*, Jan 3, 2019, <https://kotaku.com/japan-hasnt-given-up-on-the-mini-disc-just-yet-1831454992>.

⁵⁰In Teac’s international sites (e.g. mainland Chinese and Hong Kong markets), there is no MiniDisc but CD decks are on display. See “MD-70CD,” Teac, accessed Nov 6, 2019, <https://teac.jp/jp/product/md-70cd/top>.

⁵¹“Obsolescence Ratings,” Museum of Obsolete Media, accessed Nov 6, 2019, <https://obsoletemedia.org/media-preservation/obsolescence-ratings/>.

⁵²“MiniDisc Club,” Facebook, accessed Nov 6, 2019, <https://www.facebook.com/minidiscclub/>.

⁵³“The MiniDisc revival starts here (maybe),” British Library, Sept 7, 2018, <https://blogs.bl.uk/sound-and-vision/2018/09/the-minidisc-revival-starts-here-maybe.html>.

weakened. Sunlight also cause fading of information written on labels on disc cartridges. In terms of chemical components of MiniDisc media, a major part is polymer substrate, which could be affected by change of temperature and humidity, causing deformation of the physical condition⁵⁴. On the surface of MiniDisc there was a layer of lubricant. Lubricant is prone to hydrolysis in an environment with high relative humidity. Hence a dry storage space is in need.

As MiniDisc player comes to a stage of obsolescence, it is crucial to preserve the device and related software which facilitates readout of sound data. Another reason is that, because Sony had been aggressively registering patents for their vast variation of MiniDisc devices, the situation turns out MiniDisc becomes an exclusive technology and functions of related devices are exclusive as well (e.g. the magneto-optical mechanism, ATRAC, SonicStage). As a result, in preservation contexts, without preserving these devices, there is no way for archivists to extract data from the media. Other issues archivists should take into consideration include compatibility between software and computer systems in use and technical support for machine maintenance.

9. Conclusion

To certain extent, I agree with the comment that “Sony could do no wrong in consumer electronics” as mentioned at the beginning. Technologically speaking, MiniDisc not only excelled CD and cassette tapes in many terms, but also brought forth to the global market a number of sonic technology innovations. Coupling with this media format, a large variety of recording-playback devices were available in the market. The timing for Sony launching MiniDisc also seemed impeccable: at the threshold of digital age, professional and amateur users were eager for new generation of acoustic experience. However, we can also easily point out pertinent shortcomings of this media format that cause its withering. The most important reasons, in my

⁵⁴Annie Schweikert, “An Optical Media Preservation Strategy for New York University’s Fales Library & Special Collections,” (Graduate internship report, NYU Moving Image Archiving and Preservation, 2018), 13. Also see https://archive.nyu.edu/bitstream/2451/43877/2/Schweikert_OpticalMediaPreservationNYU_2018.pdf

opinion, are the inconvenient and sometimes over-sophisticated functions of MiniDisc recording-playback, and the rapid growth of other digital media formats. Ironically, Sony's ambition on MiniDisc turns out lynching this technology. Preservation of MiniDisc, therefore, is important as this media format becomes obsolete after only 10 years life.

Annotated Bibliography

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This is a post by a MiniDisc user. He gives information about why MiniDisc is not yet dead.

Baert, Luc, Theunissen, Luc, Vergult, Guido, Maes, Jan, and Arts, Jan, eds., *Digital Audio and Compact Disc Technology*. 3rd ed. Oxford: Focal Press, 1995.

A publication by Sony Service Centre (Europe), the book focuses on Sony's flagship technology of digital sound media - Compact Disc. This third edition comes with a section about MiniDisc, which is obviously regarded as a successor to Compact Disc.

Billboard. "Sony Details MD Launch at Euro Press Gathering." July 4, 1992, 47.

This is a very early MiniDisc advertisement which targeted European market. The advertisement was released from Austria where Sony's European center was located.

Billboard. "How Many 'Firsts' Can You Expect From Your Suppliers of DCC Cassettes?" Mar 13, 1993, 95.

Advertisement of Philip to promote DCC. This advertisement appeared at the same issue as Sony's MiniDisc ad. While the Philip's ad covers only one full page, Sony got two.

Billboard. "This is it." Mar 13, 1993, 92-93.

Advertisement of Sony to promote MiniDisc. The advertisement covers two full pages.

Billboard. "Newslines." Sept 21, 1996, 52.

A short brief documented Sony launched its flagship innovation - MiniDisc.

British Library. "The MiniDisc revival starts here (maybe)." Sept 7, 2018. <https://blogs.bl.uk/sound-and-vision/2018/09/the-minidisc-revival-starts-here-maybe.html>.

This blog post talks gives hints about how professional organizations could use MiniDisc as data storage media. It also introduces a historical program by BBC which used MiniDisc to store their oral history materials.

British Library. "Millennium Memory Bank." Accessed Nov 6, 2019. <http://cadensa.bl.uk/uhtbin/cgisirsi/x/0/0/5?searchdata1=CKEY5258693&library=ALL&ga=2.34071585.1282269765.1573051972-1680108785.1573051972>.

The archival entry of a BBC program which used MiniDisc as information storage media.

Discogs. "MiniDisc." Accessed Nov 6, 2019. <https://www.discogs.com/sell/list?format=Minidisc>.

This is a very gigantic platform for music lovers to exchange and trade different formats of music recordings. This is also a platform that I can find largest number of premaster MiniDisc.

Facebook. "MiniDisc Club." Accessed Nov 6, 2019, <https://www.facebook.com/minidiscclub/>.

A Chinese fans group of MiniDisc lovers. From here I can see people are still actively enjoying MiniDisc music.

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This newspaper article briefly documents the ebbs and flows of MiniDisc.

Henderson, Ken, "A rebirth in digital recording." *IEE Review* (1999): 13-16.

Henderson approves the advantages of MiniDisc and he predicts MiniDisc's positive future in European market.

Maes, Jan. *The Minidisc*. Oxford: Focal Press, 1996.

A publication by Sony Service Centre (Europe) that systematically introduces the technology of MiniDisc. It also compares MiniDisc technology and that of Compact Disc.

McClure, Steve. "Japan: MiniDisc Tops Home Recording." *Billboard*, July 24, 1999, 84.

This article described the huge popularity of MiniDisc in its domestic market. Interestingly, while the article talks about how MiniDisc enjoyed a promising future, the number of MiniDisc unit sales was actually still lower than cassette tapes.

minidisc.org. "Equipment Browser." Accessed Nov 6, 2019. https://www.minidisc.org/index.php_minidisc.org is an encompassing portal that not only provides comprehensive information about MiniDisc technology and equipments, but also a collection of anecdotes about MiniDisc. In the section "Equipment Browser", an extensive list of MiniDisc-compatible equipments is displayed. It is a very useful information portal for MiniDisc researchers and lovers.

Museum of Obsolete Media. "Obsolescence Ratings." Accessed Nov 6, 2019. <https://obsoletemedia.org/media-preservation/obsolescence-ratings/>.

A short description of the obsolescence situation of MiniDisc. Museum of Obsolete Media is a very useful and practical portal for archivists and media researchers to have a one-stop information search about different media formats, especially information about preservation.

Parsons, Jeff. "MiniDisc: The format that failed: Last Sony MiniDisc players will ship in March." *T3*, Feb 1, 2013, <https://www.t3.com/news/minidisc-the-format-that-failed>.

This music-lover piece of magazine article laments over the withdrawal of MiniDisc player manufacturing by Sony.

Patel, Nilay. "Status Symbols: MiniDisc." *The Verge*, Feb 15, 2013, <https://www.theverge.com/2013/2/15/3989872/status-symbols-sony-minidisc>.

This music-lover piece of magazine article reviews pros and cons of MiniDisc technology.

Pride, Dominic. "MiniDisc Revival Brewing Abroad." *Billboard*, July 24, 1999, 84.

This article extensively elaborated the marketing situation of MiniDisc in European market. It discussed the sales trend and how record labels reacted to premaster MiniDisc.

Pohlmann, Ken C. *Principles of Digital Audio*. 5th ed. New York, Chicago and San Francisco: McGraw-Hill, 2005.

This is a comprehensive volume that introduces a large variety of audio technologies. Composed by a music engineering professor, the book delineates from sound principles, analog to digital media, from recording technology, playback mechanism to various types of data storage formats. In particular, MiniDisc is included in Chapter 12. This book offers me a systematic tour of understanding from sound, compact disc to MiniDisc.

Ratazzi, Paul. "MiniDisc: Successful Innovation or Just Cool Technology?" Report submitted to course DSES 6470, Rensselaer Polytechnic Institute, Troy, NY, 2004.

A comprehensive research report which discusses the ebbs and flows of MiniDisc. But it is more a historical analysis than technical report.

Schweikert, Annie. "An Optical Media Preservation Strategy for New York University's Fales Library & Special Collections." Graduate internship report, NYU Moving Image Archiving and Preservation, 2018.

A systematic analysis of preservation of optical born-digital media. Unfortunately, due to the exclusiveness and obsolescence of MiniDisc, Schweikert is not able to give a detailed preservation plan for this particular media format.

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A section that displays and explains different logos that represent Sony's media products.

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This invited paper was presented by the master brain of Sony's laboratory. Yoshida oversaw the development of CD and MiniDisc. He systematically discussed the physical specification, recording-playback system and advantages of MiniDisc. This paper is a parallel version to another publications by Sony European center.

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It is regarded the first comprehensive patent documentation of MiniDisc media, with extensive introduction of several highlighted features of the technology.