

Manufacture of Pirated Compact Discs in Hong Kong

Yau-Sang Cheng, Chi-Keung Li and Pui-Shing Hung

Forensic Science Division, Government Laboratory, 88 Chung Hau Street, Ho Man Tin, Kowloon, Hong Kong

Compact discs (CDs) have gained popularity as a recording medium since the early 1980s. Owing to the low production cost and high profit margins, the medium has been a target for pirating by the clandestine "industry." This paper briefly describes the manufacturing process of a compact disc, and the identification methods used to relate a pirated CD with the stampers, mold heads and printing screens found in the clandestine CD factory. Characteristic defects introduced during the various stages of the production process, namely, the molding, design and printing, all offer excellent potential for comparative examination.

Introduction

The compact disc has gained popularity since its introduction in the early 1980's. The original CD audio specification has since been extended to include CD-ROM, CD-Interactive (CD-I), Video CD (VCD) and other formats. By now, the technology for the manufacturing of CDs has reached its maturity. Thus, the CD industry has become a low cost, high profit volume business. It has become a target for the clandestine, so-called "pirate" industry where profit margin could be measured exponentially because costs such as royalty and copyright fees, often responsible for the large proportion of the cost of a CD, are effectively waived.

Since 1997, about 30 cases related to clandestine CD manufacturing have been examined in the Government Laboratory, Hong Kong. Exhibits, including the pirated CDs, stampers, mold heads, printing screens and inks, were submitted to the laboratory's Questioned Documents Section for examination. The purpose of the examination is to establish the relationship, if any, between the production machines and the final products.

In order to determine the relationship between the exhibits, the production processes must be understood. Evidence in relation to the characteristic defects introduced during the production processes, namely, the molding, design and print-

ing could be obtained. The production processes of a CD could be summed up in Figure 1. The raw data is usually stored on videotape, licensed CD, VCD or Laser Disc (LD). The subsequent processes involve the steps of Glass Preparation, Mastering, Electroforming, Stamper Finishing, Injection Molding and Printing (Sonopress, undated).

Production Processes

Glass Preparation and Mastering

Firstly, a glass substrate in the form of a disc is prepared. After cleaning and polishing, a thin liquid layer of photoresist is spin coated evenly onto the glass. The glass substrate with the dried photoresist is called a glass master. The information from the data source (Compact Disc-Recordable [CD-R], tape, etc.) is then recorded onto the photoresist layer using a laser beam controlled by the computer. After recording, the glass master is developed and coated with an ultra-thin layer of silver in a vacuum chamber.

Electroforming

The metalized glass master is put into a tank of nickel sulphamate solution for about two hours. During this time, a layer of nickel is grown onto the silver surface of the metalized glass master. At the end of the process, the metalized glass

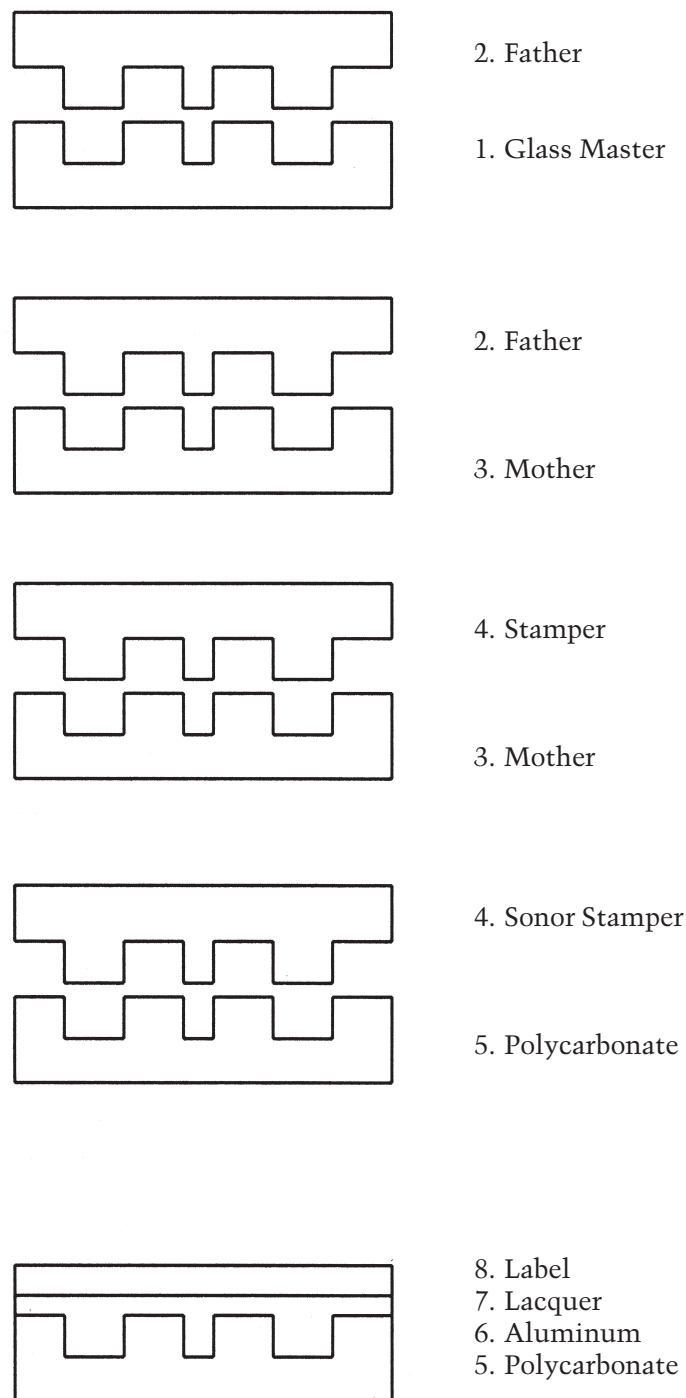


Figure 1

master is removed from the tank and the electroformed nickel sheet is separated from the silver glass master. This sheet of nickel is called the "father." The father carries the reverse image of the data. Afterwards, the father is put back into the electroforming tank for about two hours and another layer of nickel is grown. The new layer of nickel, after separation from the father sheet, is called the "mother." The mother is again returned to the electroforming tank for two hours and another layer of nickel is grown. This new layer of nickel is removed from the mother and is called the "son" or "stamper." The stamper carries the reverse image of the data, like the father, and therefore can be used for mass production of discs. More than one stamper could be grown from a mother. The stampers are then ready to be loaded into an injection molding machine for CD production.

Injection Molding

The stamper is put into an injection molding machine. Polycarbonate is heated to a molten state and injected into a mold that contains the stamper. The polycarbonate is compressed against the mold under high pressure. The polycarbonate is then cooled and a clear disc with the information embedded is removed. A thin layer of aluminum is sputtered onto the side of the disc that contain the pits or information to provide a reflective surface, such that the information can be read from the opposite face of the CD. After metalization, a thin layer of sealant or lacquer is spin coated onto the aluminum coating. The protective coating is usually dried or cured using ultraviolet light. The disc is now sealed and ready to be printed.

Printing

Most compact discs are printed by the screen printing (sometimes referred to as silk-screen) method. The screen allows ink to pass through in the shape of the desired image. Ink is pressed through the screen by a squeegee and cured using ultraviolet light.

Methods of Identification

The establishment of evidence that links pirated CDs to a production machine in a factory involves an initial preliminary examination, followed by a detailed examination.

Initial Examination

The initial examination includes the comparison and matching of any markings including the International Federation of the Phonographic Industry (IFPI) numbers near the hub of a CD/VCD (Figure 2) with those on the stamper and the mold head. This examination can be done visually or with the assistance of an ordinary stereomicroscope. Discrepancies in the font type or contents immediately rule out any relationship. Agreement in contents and font type warrants further detailed examination.

Detailed Examination

The detailed examination includes the comparison of the fine details including defects on the CD/VCD (Figure 2), stamper and mold head. Printing details and defects on a screen can also be compared with the printing on a CD/VCD.

The physical characteristic defects that link the stamper and the CD products are usually due to minute imperfections. Since the defects are minute in size and marked on a flat reflective surface, a Nikon Optiphot 150S metallurgical microscope equipped with a "Universal Epi-illuminator10" was utilized for this examination. The defects were observed in brightfield mode using a "CF Plan BD DIC" objective lens at magnifications of 5X, 10X and 20X. This microscopic setup enables the observation of the specimen's natural color and form. The optical images of the defects were captured with "Microflex FX series" photomicrography equipment adapted to a 35mm camera.

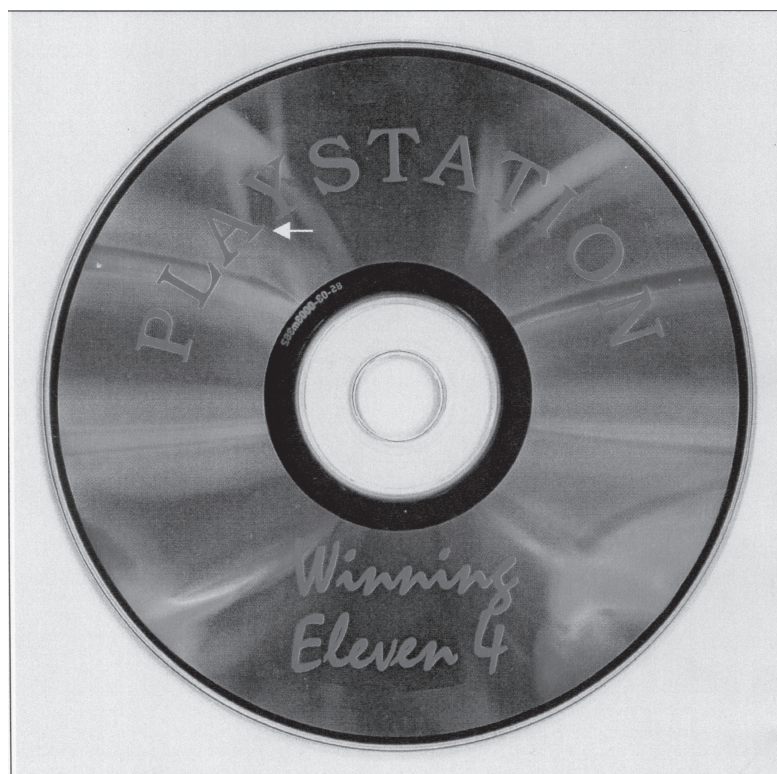
The production of pirated CDs always lacks quality control and defects due to careless handling, contamination from airborne dust and dirt which are invariably introduced during the stamper replication process (Figure 3). In addition, the microscopic pattern and details of the code number engraved near the inner hub of the non-printed face of a CD also provide a unique identification clue (Figure 4). Since this micro-size code number is sealed with the lacquer or the printing pattern, it is conveniently observed from the clear and non-printed face.

The mold head contains the source identification (SID) code of the factory. It is mounted with the stamper on the injection molding machine during the CD manufacturing process. The SID code is laser engraved onto the mold heads. Therefore, similar to stamp impression comparison, any



FRONT

- (1) CD code number
- (2) SID code number
- (3) Defects randomly located on the CD



- (4) Silk-sceen printing

Figure 2

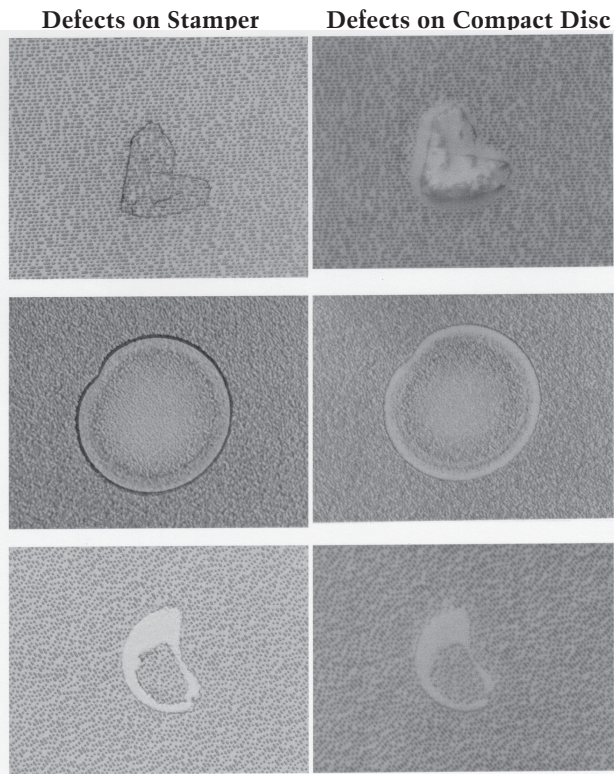


Figure 3

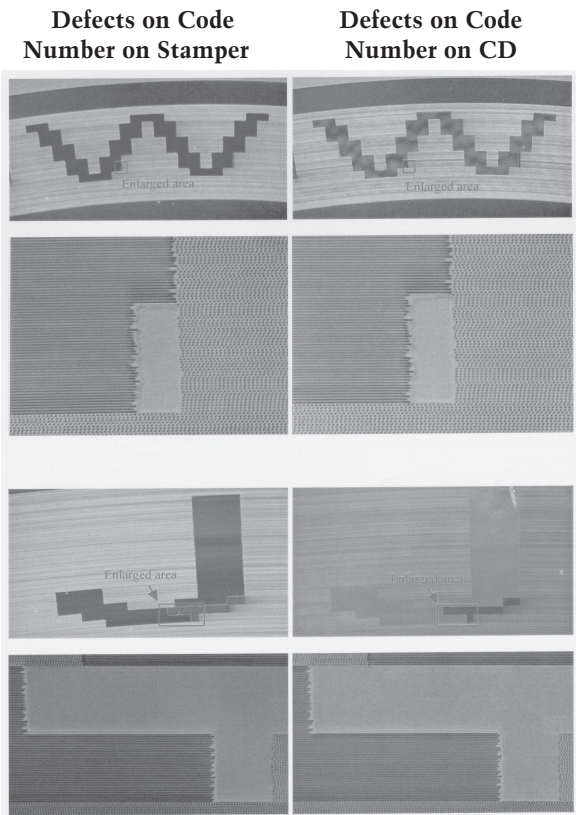


Figure 4

defects located on the mold heads in relation to the SID code and/or any manufacturing defects are reproduced on the CDs (Figure 5).

The printing defects of the screen printing are defects introduced during the production processes, including the design of artwork, preparation of the film (usually a positive transparency) of the screen, and the printing process. A characteristic defect present in the artwork design pattern may be in the form of minute voids, dust and even spelling mistakes (Figure 6).

Discussion

The methods utilized for the identification of compact discs are analogous to those used for the identification of rubber stamp impressions. It is based on the location of common defects found on the discs, stampers and mold heads, and printing screens. The manufacture of compact discs is a rather sophisticated process whereby cleanliness is of paramount importance. However, in a clandestine factory, attention to such stringent work-

ing environment is rarely paid and minute defects are often introduced during the manufacturing process. The defects are randomly introduced and will be inherited by the pirated CD/VCDs. The presence of such defects can provide solid evidence to link the stampers and mold heads to the compact discs.

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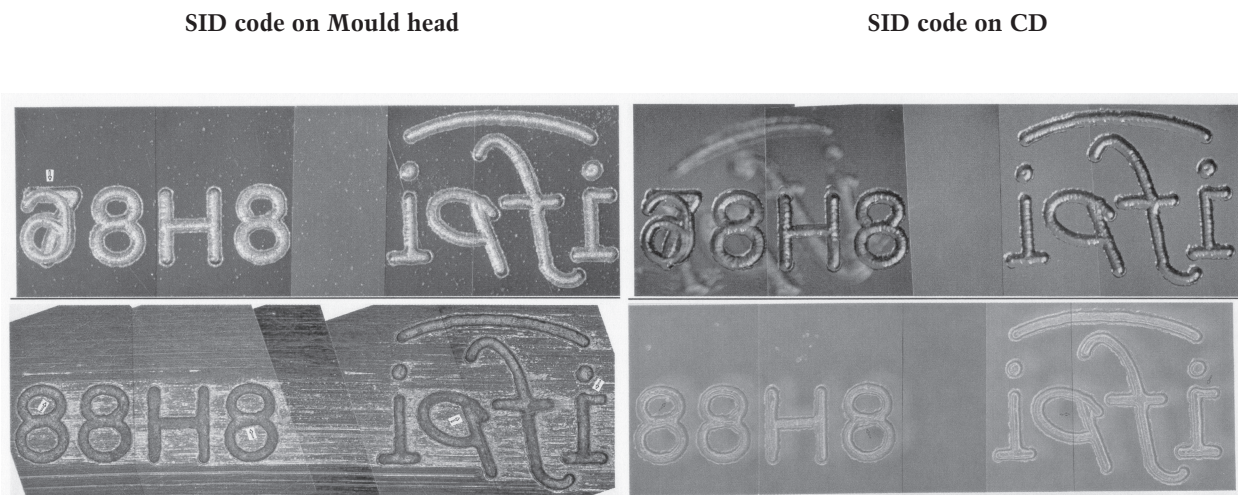


Figure 5



Figure 6