UROS Research Report

Fingerprints on digital media – determination of the order of deposition

An Investigation into the Development of Fingerprints on CD-ROMs Following Laser Exposure during Data Burning.

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Abstract

Previous work has looked at heat treatment of fingerprints and how heat exposure can affect a deposited fingerprint. This study looked at the application of that idea to fingerprints on a CD containing incriminating data which could used as evidence. It investigated whether it could be determined that the person handled that CD prior to data being burned onto it.

Following sampling and development of groomed fingerprints using superglue fuming and powder suspension development, it has been suggested that these methods alone cannot distinguish if a fingerprint was deposited onto the CD before or after data was burned on to it, following 24 hours or 14 days of storage.

Further experimentation showed that the CD burning process did not cause fingerprints to fluoresce when observed under QUASER light of wavelength 352nm-509mn (using a 510nm viewing filter). This has very limited application to the initial aim of the study. Despite this, fluorescence was observed on fingerprints deposited on paper when exposed to temperatures of 150-170^{o}C for a duration of 15-20 minutes, although these observations were not quantified and were across a limited sample range. It does show, however, that heat exposure will cause components within eccrine secretions to fluoresce so there must be some form of physical change taking place.

While this study did not provide any viable method to detect if a fingerprint was deposited on a CD before or after the burning process, it did suggest that powder suspension, superglue fuming and fluorescence are poor choices and that heat exposure to a certain degree does change the composition of fingerprints through suspected thermal decomposition of constituents of eccrine secretions. Other development techniques and methodologies such as chemical analysis would be the areas to research further to develop a viable method to meet the aim of this research

Introduction

In today's age of digital technology and data storage, CD-ROM's are now commonplace to store a variety of important and trivial information. With affordable, durable and simple means in which to store data, CD-ROM's are now part of daily life, both in the office and at home. As this digital age develops, criminals also are making the transition to digital media, with the connectivity and portability of modern technology and computer equipment the distribution of illegal data such as music, films, indecent images, and fraudulent documents has become much more widespread. When the people responsible are brought to court for possessing illegal data on such media, often the defence is that any fingerprint evidence recovered from the CD-ROM was simply due to handling the blank media before any information was transferred to it. This is a very difficult defence to disprove without any viable means to test if a fingerprint was deposited before or after the data was “burnt” to the disc. If such a method exists or can be discovered then the defence of “before and after” would not stand as strong to a prosecution and the relevant experts could support or oppose the claim. Using development techniques that are sensitive to the burning process would be the ideal, such as a cheap and easy method of development that would identify whether or not the disc was burned before handling.

CD-ROM technology utilises a very thin track of data forming a spiral from the centre of a disc to the outside edge. This data track is stamped via a series of bumps onto a layer of polycarbonate plastic to provide structure and protection, and on top of this a sheet of aluminium is applied to provide a reflective surface above the track. To protect the metal a layer of acrylic is then placed on top (Figure 1).

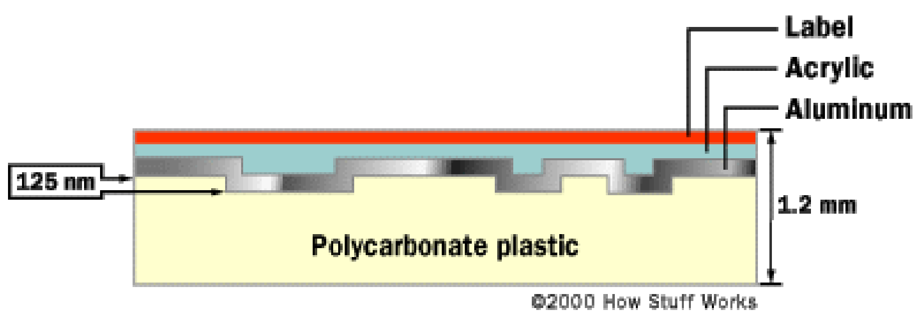


Figure 1 – Cross sectional area of a factory manufactured CD
[Taken from [http://electronics.howstuffworks.com/cd1.htm] accessed online 13/9/2011]

With the manufacturing process to actually stamp the track into the plastic requiring specialist equipment and machinery it was not viable to offer this as a home solution. With the development of home hardware capable of recording and reading CD-ROMs a new design of disc was created. These new discs have a layer of dye rather than the stamped track. This dye will become opaque when exposed to high temperatures of around 150-200^{o}C. This allows a home CD burner to use a laser to “burn” the data to the disc. The temperature is what the dye needs to reach not necessarily the temperature output of the laser. The standard laser used for CD burners has an output of around 650nm at 140mW. The dye used in the discs is commonly cyanine which crystallises at 200^{o}C. This gives the approximate temperature the fingerprints are exposed to of around 150-200^{o}C. The only limitation of this approximation is that on a standard 700MB disc, the laser will only pass over any given point for a fraction of a second and the heat will quickly dissipate over the substrate. Polycarbonate has a glass transition of 150^{o}C. This would suggest that the temperature would not exceed 150^{o}C or the CD's would lose their rigidity and become malleable.

With regards to fingerprints on the CD, it could be suggested that during the burning process the fingerprints are exposed to the high temperature of the laser as it passes through the plastic. If this heat exposure was sufficient to cause a detectable chemical and/or physical change to the fingerprint, then this would allow the suggestion that the fingerprint was deposited either before or after the burning process.

One key aspect for this study is what exact temperature the fingerprints are exposed to during the burning process, as this is what would cause physical and/or chemical changes to the composite components. As stated previously, the melting point of the polycarbonate used in the manufacturing process is a limiting factor for the heat levels involved. Despite this, work has been conducted to suggest that selected fingerprint residue components were still detectable after pyrolysis at 350^{o}C for 5 minutes, (Richmond-Aylor *et al*., 2007) along with the suggestion that an alternate development reagent was shown to yield better results at these temperatures. This would suggest that a degree of chemical or physical alteration has taken place to allow a change in the reactions that occur with development agents.

Additionally a further look into the effects of heat on sampled fingerprints with regards to fluorescence was completed. This again is subject to heat exposure. Previous studies have shown that eccrine heavy prints that are exposed to 120-200 ^{o}C for 20 minutes develop fluorescence under high intensity light of a discreet excitation wavelength range of 352nm-509mn and viewed using a 510nm viewing filter (Dominick *et al*., 2009).

Materials & Methods

Fingerprint samples were deposited directly onto the data side of CD-ROM's, along with control samples deposited onto acetate strips. Twelve individuals from staff and students on-site, across a wide age range with a mix of male and female were used as fingerprint donors. Sebaceous-loaded fingerprints were deposited following rubbing the fingertips across the nose and forehead areas. The samples were deposited as an alternate depletion series across both the control strip and the CD.

Following sampling the "before" samples were then "burned" using the CD-Burner to expose them to the write laser. The data used was simply a high resolution image, copied multiple times to reach the 700MB limit of the CD, to ensure the laser would cover the entire radius. For the "after" samples, data was burned to the CDs before fingerprints were deposited following the same procedure described above.

This was repeated until 30 CDs were sampled, divided into 2 per board, one sampled before burning and one sampled post burning. Each board was developed using a different technique, and each one repeated three times.

Figure 2 - Sampling setup, post development, with fingerprints for each participant limited to an area marked on both the acetate and the CD

The development techniques used were

1. Superglue fuming using a Mason Vactron MVC 5000 superglue cabinet (Foster & Freeman) and according to the Home Office Manual of Fingerprint Development Techniques (Bowman, 2009).
2. Wet Powder White (Kjell Carlsson Innovation)
3. Wet Powder Black (Kjell Carlsson Innovation)
4. Titanium dioxide white powder suspension – prepared according to Burns (1994)
5. Iron oxide black powder suspension – prepared according to the Home Office Manual of Fingerprint Development Techniques (Bowman, 2009).

All treatments were conducted following SOP's respective of their individual manufacturers. Following development, the fingerprints were recorded and scored as discussed in the results section. The entire study was repeated with the samples being stored for 14 days before development in the second instance.

<u>Results and Discussion</u>

Once the fingerprints were developed under the standard operating procedures as stated, they were observed under hand magnifying lens under natural light and the quality measured using a scoring method outlined in Table 1 developed by the Home Office (Bandey and Gibson, 2006).

Score	Fingerprint quality
0	No print developed (not visible to the naked eye)
1	Less than 1/3 of the print visible
2	Less than 2/3 of the print visible but more than 1/3
3	Less than a complete print but more than 2/3
4	Full print developed and visible

Table 1 – Fingerprint scoring method (Bandey and Gibson, 2006)

From these results the number of usable prints (scored ≥ 3) was calculated following the quantification of all techniques combined. There was no difference in development between development techniques (Figures 3 and 4).

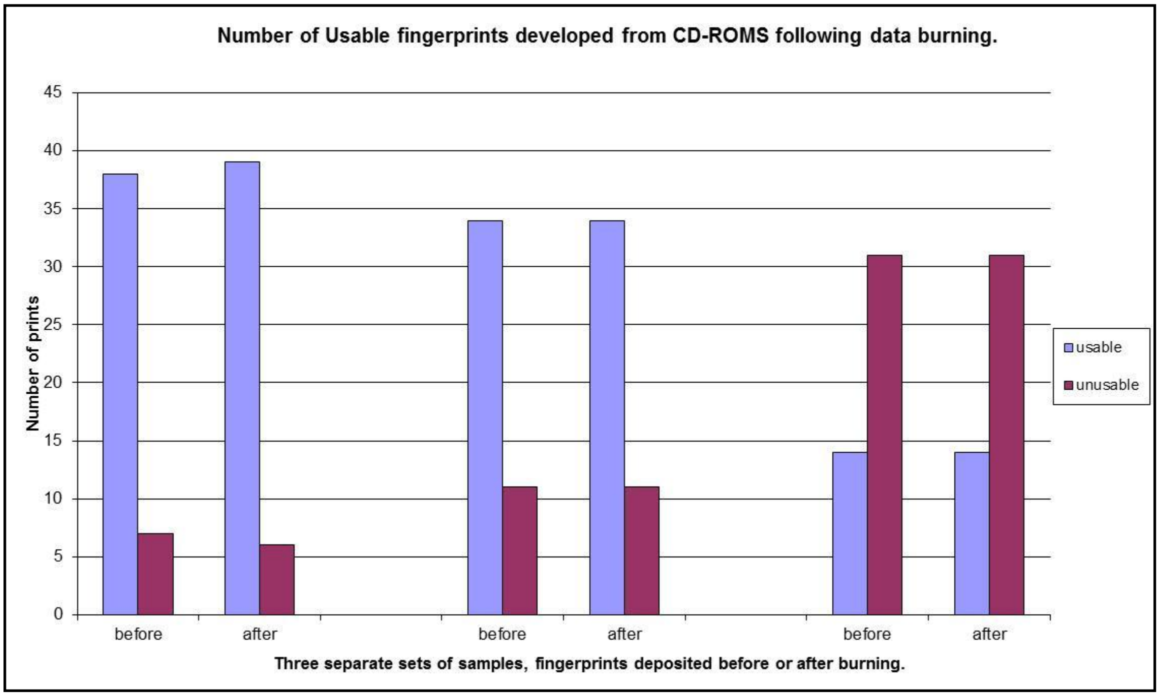


Figure 3 - Quantification of usable prints after 24 hours

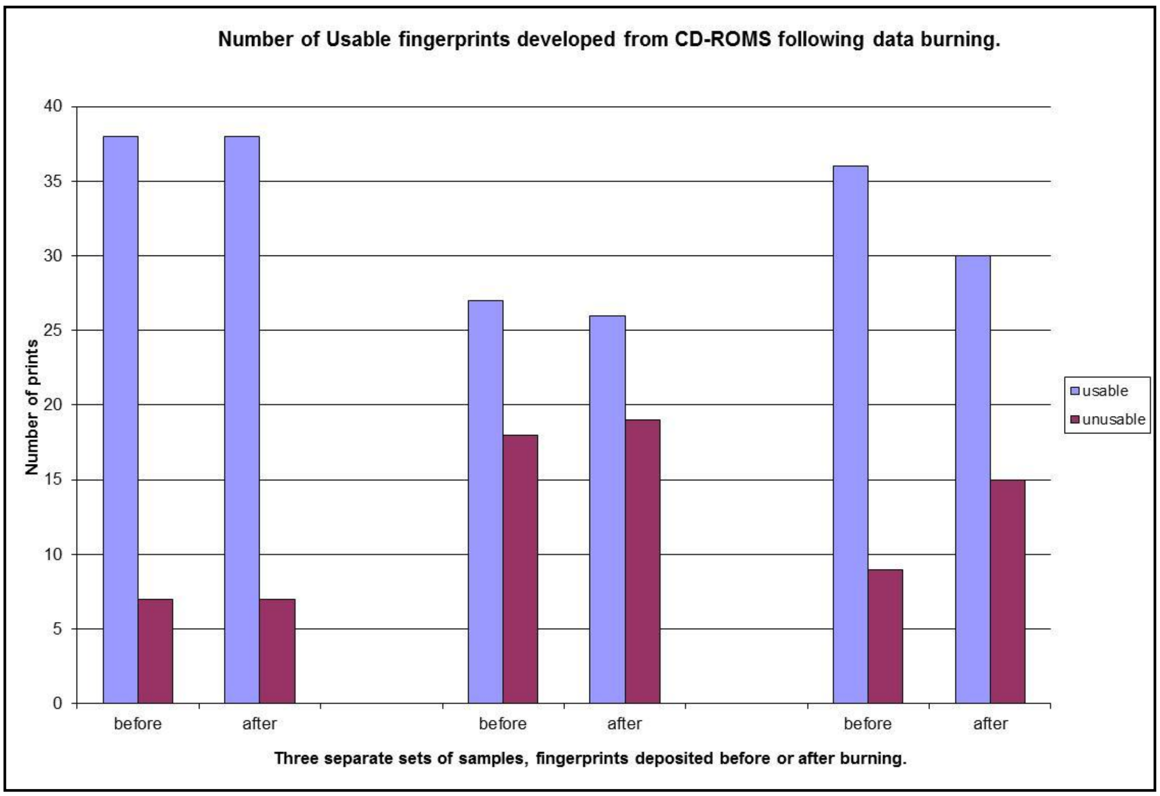


Figure 4 - Quantification of usable prints after 14 days.

From these results it is suggested that there is no variation in the quality of enhancement between a fingerprint being deposited before or after a CD has been burned. Although this is limited to the development techniques used, it was noted that there were no distinguishable difference between techniques, the substrates used and the methodology used.

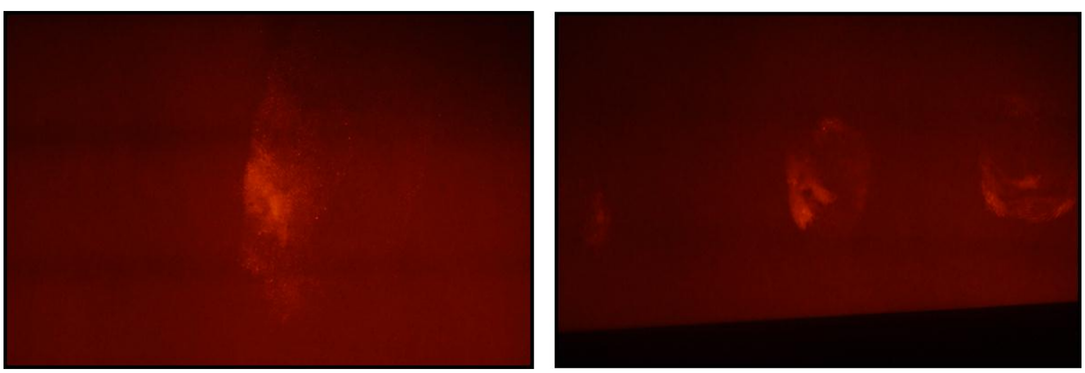
It is suggested that the lack of differentiation between before and after, could be due to the output heat of the laser not reaching a threshold in which the samples would undergo physical changes, or not any that are detected using these development methods.

It is noted that despite a large sample number (>300 fingerprints), the actual number of donors was limited to 12 individuals and all were selected from the same professional background and working environment. This may cause some degree of bias towards sampling a general population. To make this less of a concern the samples were taken from a wide age range (19-52 years) and both male and female donors.

These results do display the amount of variation between donors, with large variation in the number of usable prints, using the same methodology, but generally giving usable results after both 24 hours and 14 days.

Following the observation of the samples under an intense light source, the only samples to yield any detectable fluorescence on either a CD or standard copier paper were those that were heated at 150^{o}C for 20 minutes and at 170^{o}C for 15 minutes. There was no observable fluorescence with any natural print samples that had not been heated. There was also no observable fluorescence below this temperature range. At any temperature above 180^{o}C the CD melted and became untestable. There was no observable fluorescence at exposure times below 15 minutes at any tested temperature.

Figure 5 – Fluorescence of fingerprint samples.



[LEFT IMAGE -*Fingerprint exposed to 352nm-509mn light under a 510nm filter. Following exposure to 150^{o}C for 20 minutes.]*
[RIGHT IMAGE -*Fingerprint exposed to 352nm-509nm light under a 510nm filter. Following exposure to 170^{o}C for 15 minutes.]*

This was evident in both the CD-ROM and the sheet of paper. No other temperature yielded positive results. This does coincide with Dominick *et al*.'s (2009) work into heat-exposed fingerprints but does give an initial suggestion, despite the limitations, of the actual temperature does not need to be as high if the duration is extended. This might lead towards a relationship between temperature and time with regards to fingerprints and fluorescence, but that is just an idea at this stage and would require more focused research into that area. Higher temperatures at a lower time period may be more applicable to model how a CD burning laser would operate but any CD's exposed to any higher temperatures began to melt and liquefy.

Again this portion of the investigation is under the same limitations of sample variation within the population and the similar professions and working environment. While the eccrine heavy prints are more susceptible to variation of the individuals' make up of eccrine secretions, the relatively low sample number may not represent the population as a whole and needs to be considered with these findings.

Again compared against early work conducted the suggestion that fluorescence is only observed following exposure to a narrow temperature range gives evidence that the chemical make-up of eccrine secretion is what causes the fluorescence, following the research done into pyrolysis of the components of fingerprints (Richmond-Aylor *et al*., 2007) has produced possible thermal decomposition components which when applied to the work on fluorescence gave the possibility of those specific molecules would fluoresce, namely 2,5-furandione and maleimide but not conclusive (Dominick *et al*., 2009). It was noted that a number of components including ammonia following thermal decomposition, or an intermediate component is what causes the fluorescence but was not specified within the referenced literature. Considering the evidence stating that the composition is the key factor with fluorescence, with eccrine amino acids giving a greater degree of fluorescence opposed to fatty acids of sebaceous.

Conclusions

It has been suggested from the results that enhancement techniques such as powdering and powder suspensions cannot distinguish between fingerprints that were deposited before or after a CD-ROM has had data burned onto it using a standard burning optical drive, at least in the capacity of visual observation alone.

Fluorescence can be observed from fingerprints following exposure to heat of temperatures ranging from 150-170^{o}C for a duration of 15-20 minutes via heating in an oven. But following exposure to the burning process no fluorescence was observed, providing no use in determining if the sample was placed before or after burning.

Chemical changes may be detectable but would require research focused in this area, such as Fourier transform infrared spectroscopy or similar methods. As far as the results from this study go, there was no methodology or technique to confirm the order of fingerprint deposition and data transfer to the CD.

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