



An Elemental Analysis Of Different CD-R Discs

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ABSTRACT

In this study Proton Induced X-ray Emission (PIXE) and Rutherford Backscattering Spectrometry (RBS) as reliable and non-destructive techniques has been applied to compare thickness, major and trace elements of different brands of CD-R discs. Three elements, namely Ag, Ba, and Ti were found to be the major elements.

Keywords: RBS technique; PIXE technique; CD-R disk; Label side (up); Record side (down).



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INTRODUCTION

Nowadays a large number of analytical techniques have been developed for quantitative elemental analysis of all types of samples such as environmental, industrial, medical, geological etc. Some techniques, namely, atomic absorption spectroscopy (AAS) and chemical analysis destroy the identity of sample and hence are destructive. However, there are also some non-destructive techniques.

Among non-destructive analytical techniques, Particle Induced X-ray Emission (PIXE) is a highly sensitive, multi-elemental analytical technique which is already proved in all prospective areas such as thin films, water, air, archaeological and biological samples etc. This technique works on the principle of creation of inner-shell vacancies in the target element and measurements of the x-rays emitted from the sample by using semiconductor detectors [1-5]. PIXE can only be used for detection of elements in the range $11 \leq Z \leq 92$ because the energy of the characteristic x-rays emitted by low-Z elements is so low to be detected by presently available detection system. In this technique, elements with $11 \leq Z \leq 50$ are generally determined through their K x-rays and the other heavy elements are measured through their L x-rays due to large L (i=1-3) subshell cross-sections.

PIXE can be coupled with other ion beam analysis techniques, such as Particle-Induced Gamma-ray Emission (PIGE) and Rutherford Backscattering Spectrometry (RBS). Rutherford backscattering spectrometry, as a technique to address thin film properties in materials research, has evolved from classical nuclear physics experiments conducted during the first half of the previous century [6-7]. In this work we use PIXE and RBS techniques to analyze different types of CD-Rs.

CD-R is short for CD-Recordable and is a writable disc and drive that is capable of having information written to the disc once and then having that disc read many times after that. CD-Rs are a low cost solution for backing up software. Each CD-R is capable of holding up to 650 MB (74 minutes of music) or 700MB (80 minutes of music). A standard CD-R is a 1.2 mm (0.047 in) thick disc made of polycarbonate about 110 mm (4.7 in) or 80 mm (3.150 in) diameter. The 120 mm disc has a storage capacity of 74 minutes of audio or 650 Megabytes of data. The polycarbonate disc contains a spiral groove to guide the laser beam upon writing and reading information [8-10].

The basic building blocks of CD-R media are organic dye and a reflective layer. The dye types currently in use are:

- cyanine dye, which is cyan blue in color (hence the name);
- phthalocyanine and "advanced" phthalocyanine dye, which have a faint aqua tinge;
- metalized azo, which is dark blue.

MATERIALS AND METHODS

Sample preparation

Using cutter the samples with size about 2cm×2cm from the label side were suspended on aluminum sample holders with holes at the center as shown in Figure 1. International Atomic Energy Agency (IAEA) MA-B-3/TM Fish tissue was used as a standard for calibration of PIXE set up.



Figure1: CD samples from the label side (up) and the record side (down)

Equipment and measurement

The 3.0 MeV van-de-Graff electrostatic accelerators at physics and accelerators research school, placed at Atomic Energy Organization of Iran, were used for the RBS and PIXE measurements. The beam spot diameter on the sample was 6mm and the beam current was 5 nA. In the RBS and PIXE techniques, measurements were carried out in vacuum (10^{-6} Torr) by irradiation with beams of 1.5 and 2.0 MeV energy proton ions. Using mechanical and diffusion pumps, required vacuum was prepared. Because of carbon resonance, using beam of 2.0 MeV energy proton ions was given complicated spectrums. So spectrums made from 1.5 MeV proton ions just were analyzed. Generally structure of layers and resonance effects determine type and energy of beam. The samples were placed normally with respect to the incident beam. To analyze many samples without breaking the vacuum, a cassette type of sample installing system was used, where 16 sample holders could be loaded at once.

A surface barrier detector was normally mounted in a backscattering angle 165° from the incident beam. A Si (Li) detector at 135° detected characteristic X-rays emitted from the targets. A $175\ \mu\text{m}$ -thick Mylar absorber was positioned in front of the detector in order to decrease the intense low energy X-rays originating from the matrix elements, while the light elements were detected without an absorber. The energy resolution of detector was 175eV at $5.9\ \text{KeV}$. The solid angle was limited to be $3.3\text{e-}3\ \text{sr}$ that was corrected by one of the available calibration techniques. The PIXE and RBS spectra were collected with conventional electronics and a multi-channel analyzer. A reference sample was used to determine the PIXE parameters.

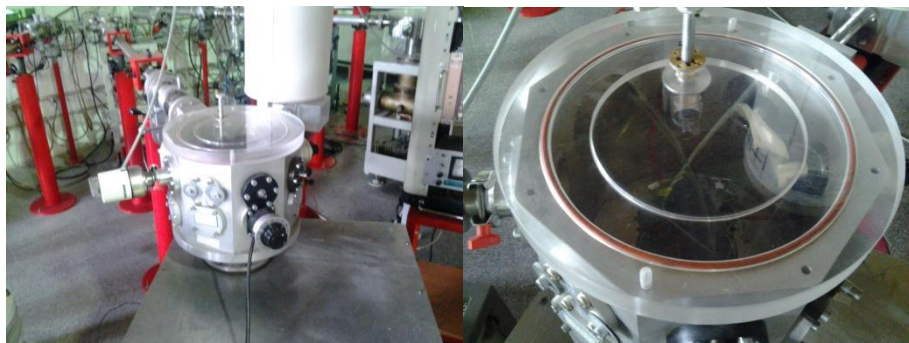


Figure 2: Schematic of the ion beam, target, and detectors arrangement in the RBS and PIXE chamber used for measurements

The RBS and PIXE spectrums analysis was performed using SIMNRA and GUPIX codes respectively. Data obtained from the computer program were net peak areas of K and L shell X-ray (figure 1); errors are coming from counting statistics and values for the background. Since the spectra of low Z elements and high Z elements were obtained separately, they must have been calibrated according to the efficiencies of the detector for calcium and iron. Then, these two elements were chosen for comparing the two PIXE spectra obtained with and without absorbers for the specific samples. In this way, the two spectra were matched after charge correction.

RESULTS AND DISCUSSIONS

The RBS and PIXE spectrum analysis showed that the major elements Ag, Ba, and Ti were quantified in the CD-R samples. In Table 1, all of the major elements Ag, Ba, Ti, and the trace elements Al, Mg, Si, S, Cl, Ca, Ti, Cr, Fe, Cu, Sr, Au, Hg have been observed in the different CD-R samples.

Table 1- Major and Trace elements in different brands of CD-Rs

<i>CD mark</i>	<i>Major elements</i>	<i>Trace elements</i>
Memorex	Ag-Ba	Mg-Si-S-Cl-Ca-Fe-Cu-Sr
Pacific	Ag-Ti	S-Cl-Ca-Cu
Digimax	Ag	S-Cl-Ca-Ti-Cr-Fe-Cu
Sony	Ag-Ba	Al-S-Cl-Ca-Ti-Fe
Kodak	Ag	S-Cl-Ca-Ti-Fe-Cu-Au
NT Nortek	Ag-Ba	Si-S-Cl-Ca-Ti-Fe-Sr
LG	Ag-Ba	S-Cl-Ca-Ti-Fe-Sr-Hg
Creation	Ag-Ba	S-Cl-Ti-Cr-Fe-Cu
Data life (yellow color)	Ag-Ba	S-Cl-Ca-Ti
Data life (white color)	Ag-Ba	Si-S-Cl-Ca-Sr

When simulated spectrum is fitted with the experimental spectrum, it is possible to measure thickness of the second layer. Thickness of the second layer in different CD-Rs has been shown in Table 2.

Table 2- Thickness of second layer (reflecting layer) in different brands of CD-Rs

<i>CD mark</i>	<i>Thickness of Layer ($1\text{E}^{15}\ \text{At/cm}^2$)</i>
Memorex	1000
Creation	2000
Digimax	2000
LG	1900
Sony	1900

The RBS spectrums analysis was performed using SIMNRA code. Figure 3 shows RBS analysis of typical sample of the record side, while Figure 4 gives its corresponding analysis of the label side.

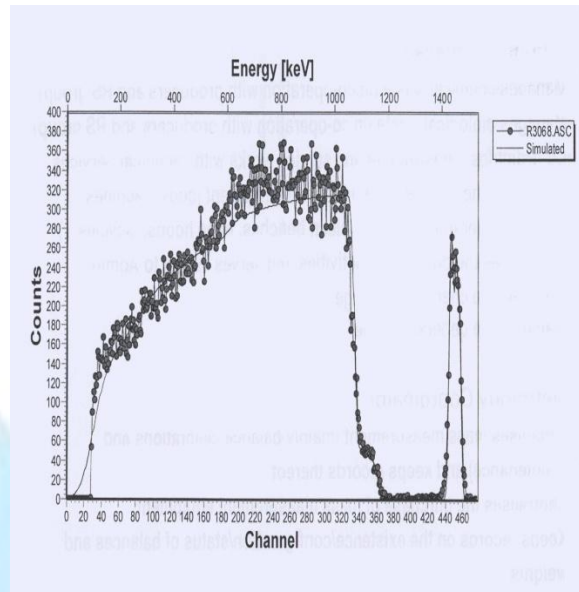


Figure 3: Typical RBS spectrum of the record side of CD sample

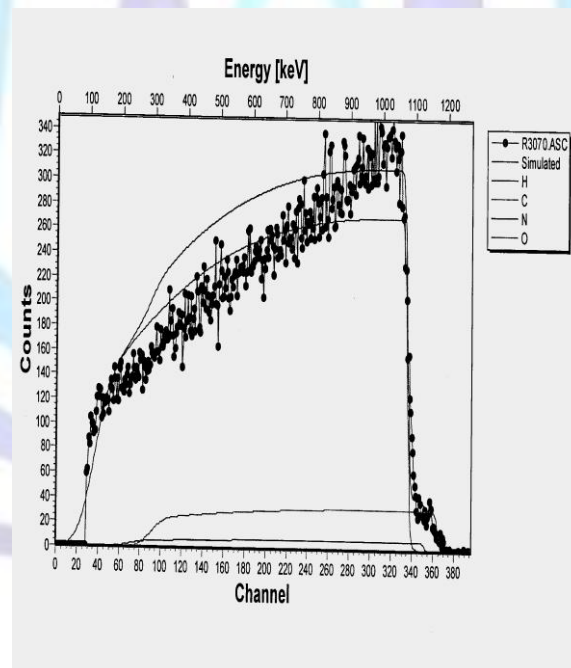


Figure 4: Typical RBS spectrum of the label side of CD sample

CONCLUSION

In this work, the main objective was to demonstrate the suitability of PIXE and RBS techniques for determining and measuring elements present in the CD-R samples. In the present work, elemental analysis of CD-R samples was performed using GUPIX and SIMNRA codes.

Comparing original elements observed in the different brands of CD indicates that all companies use silver metal in making CDs in an alloy form as reflector of laser light from CD. It can also be seen that Barium metal almost exists in the first layer of different brands of CDs.



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