



Characterization of liquid crystal displays
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Resumo

A tecnologia utilizada na fabricação de televisores e monitores vem mudando nos últimos anos. O monitor de cristal líquido (LCD) chegou ao mercado para substituir os monitores de tubos de raios catódicos (CRT), o que faz com que o aumento das vendas deste tipo de tecnologia deva manter-se pelos próximos anos, e desta forma o descarte deste tipo de produto também irá aumentar.

A atual forma de disposição destes monitores são os aterros e a incineração, bastante utilizada em países desenvolvidos. Desta forma, sem o correto conhecimento dos componentes e materiais presentes em um LCD deixa-se de reutilizar, reciclar e recuperar materiais como mercúrio, polímeros termoplásticos, metais preciosos, entre outros permitindo também a contaminação do solo, água e ar a partir da liberação de compostos tóxicos presentes neste tipo de resíduo.

A correta disposição / tratamento da sucata pode evitar não só a contaminação do meio ambiente como também evitar o consumo de recursos naturais e agir como um estabilizador de preço destes produtos.

Desta forma o objetivo deste trabalho foi caracterizar os materiais presentes neste tipo de resíduo, identificando composição, quantidade e forma a fim de permitir o desenvolvimento de rotas de reciclagem.

Palavras-chave: Monitor de LCD. Caracterização. Sucata eletrônica.

Área Temática: Resíduos Sólidos

Abstract

The technology used in the manufacture of televisions and monitors has been changing in recent years. The liquid crystal display (LCD) came to market to replace the monitors cathode ray tube (CRT), which makes the increase in sales of this technology should maintain for the next years, and thus the disposal of this type of product will also increase.

The current form of disposal of these monitors is landfill and incineration, widely used in developed countries. Thus, without the correct knowledge of the components and materials in an LCD, the reuse, recycle and recover materials, such as mercury, thermoplastic polymers, precious metals, among others, are disadvantaged, also allowing the contamination of soil, water and air from the release of toxic compounds present in this type of waste.

The correct disposal / treatment of scrap can not only prevent contamination of the environment but also avoid the consumption of natural resources and act as a stabilizer price of these products.

Thus the objective of this study was to characterize the materials in this type of waste, identifying composition, amount and form in order to enable the development of recycling routes.

Key words: LCD monitors; Characterization; Electronic Waste



Theme Area: Solid Waste

1 Introduction

The development of new technologies such as thin film transistors (TFT) made possible the emergence of new types of monitors. The liquid crystal display (LCD) is the main application of this technology. LCD screens are present in various electronic devices, including the displays of mobile phones, tablets, televisions, computer monitors and other.

In Brazil, in August 2010 was instituted the National Policy on Solid Waste (PNRS) based on the concepts of:

- Shared responsibility,
- Reverse logistics and
- Life cycle of the product.

Among the objectives of this law is the not generation, the reduction, the reuse, the recycling and final treatment of solid waste. Another objective is the correct final disposal of the rejects, the reduction of volume and hazardous waste (PNRS, 2010). However, this law is not yet being applied in its entirety.

In Brazil there are no studies specific to the monitor market, so there is no way to estimate the volume of sales. However, considering that for each computer one monitor will be sold, only in the first half of 2011, 7.4 million computers were sold in Brazil, which makes the country the third in the world computer market behind only the United States and China (IDC BRASIL, 2011).

In emerging countries such as Brazil, the continuous increase in sales of LCD monitors is due to the replacement of the monitors cathode ray tube (CRT) and in the coming years this growth estimate should remain. Thus, the increase in waste generation of computers, which in 2008 reached 105,000 tons (ARAÚJO, 2012), will also increase..

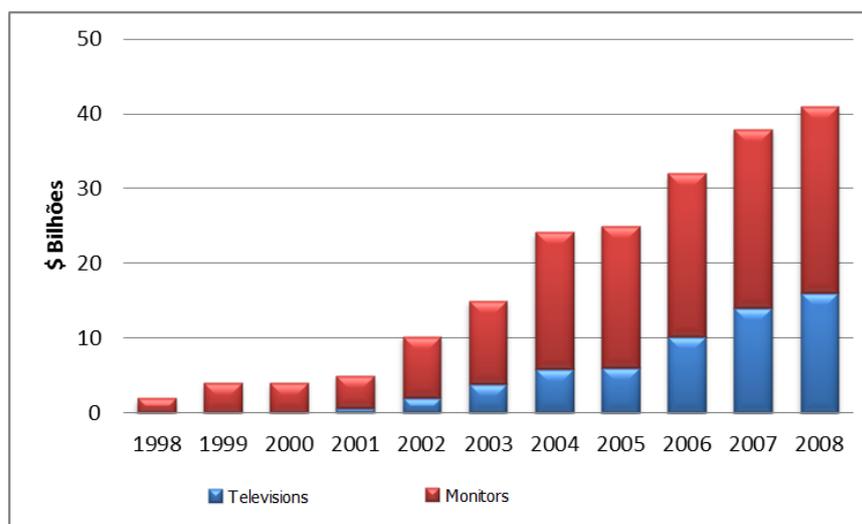
LCD monitors are lighter, thinner, having higher energy savings and it does not emit radiation in relation to the CRT. The basic mechanism of operation is given from blocking the light from the back of the screen. An LCD screen is formed from two pieces of polarized glass filled with liquid crystal molecules that lie between the solid and liquid state, also known as mesophase. A backlight passes through of the first polarized glass, while, electrical currents cause the liquid crystal molecules align to form the variations of light that pass into the second polarized glass and so there is the formation of color images.

In order that the reuse and recycling of scrap LCD can be done successfully is necessary to ensure that these components are known. Also is need to replace the final destination of products, mostly to landfills, and introduce an approach to reuse and recycling.

This work aims to characterize the components present in LCD monitors for a correct disposal can be performed after the end of life of the equipment. This technology was chosen due to the trend of increasing use as shown in Graphic 1, that shows the increasing use of LCD monitors and televisions in the world and also because the monitors LED (light emitting diodes) that are likely dominate the market in the future, have only few differences in structure compared to the LCD.



Graphic 1 - Use of LCD in the world



Source: DisplaySearch (2004).

2 Materials and Methods

To perform this work were initially collected 30 monitors and screens obsolete and / or damaged in various brands and models.

The LCD monitors (7 entire LCD), ranging between 15 and 19 inches of various brands, as can be seen in Table 1, were manually dismantled. From the variety of brands and sizes of screens it was possible to observe the main structure of the monitor, as well as determining the differences in materials and weights according to the manufacturers studied. With the determination of these variables can be defined if all the machines can receive the same destination process of segregation of parts at the end of life.

Each monitor has been previously weighed and then was disassembled from the back, removing the screws, opening the monitor, removing printed circuit board (PCB) and dropping the monitor base. As the pieces were being removed, these were identified in two groups: frames and parts of interest. The first group consisted of the polymer part of the external monitor, as well as cables, metal parts and screws. The second group consisted of the materials present on the LCD screen, PCB and lamps. The polymer layer present in the glass layers were separated being placed in acetone for about 2 hours at room temperature (TAVARES, 2006).

After separation of the parties present on the monitor, analysis of characterization was performed using optical microscopy, scanning electron microscopy (SEM) and Infrared (IR).

Table 1 – Monitors used

Monitor	Size	Monitor	Size
CCE	14"	Samsung	19"
Samsung	15"	LG	19"
Unmarked	15"	LG	19"
LG	17"		

3 Results

After the separation process it was observed that the structure that is equal on all monitors is as follows:

- Front cover,

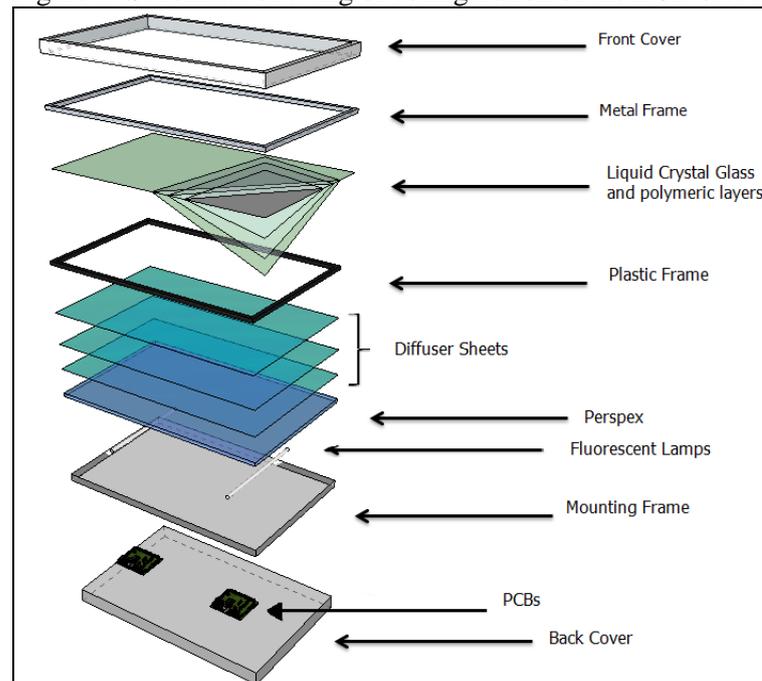


- LCD screen,
- PCB,
- Back cover.

The LCD screen consists of a metal structure, plastic frame, diffuser sheets, Perspex sheet, fluorescent lamps, PCB, reflective sheet and two layers of glass with liquid crystal between. Each glass layer is composed of three polymeric layers. After the polymeric film has been placed in contact with acetone, there was the separation of the film in three phases: a dark polymeric material (a), another of a material with texture gel (b) and the last phase was obtained only after the evaporation of acetone (c). All layers present on the LCD monitor can be observed in Figure 1, which shows a schematic drawing of configuration of the LCD screen. This configuration may have slight variations according to the manufacturer, model and size of the monitor.

The differences found in the structures are between the number of printed circuit boards and the presence of steel plates found in some brands between the LCD screen and PCBs. The differences between the weight ratios found for monitors with same screen size is mainly because the base is larger and heavier compared to other models.

Figure 1: Schematic drawing of configuration of the LCD screen



The constituents of the monitors that are polymeric material, all are thermoplastic and have identification showing the type of polymer present. The front cover and back cover of the monitor is a blend of Polycarbonate (PC), Acrylonitrile Butadiene Styrene (ABS), Polymethyl Methacrylate (PMMA) and flame retardant halogen free. The plastic frame is only made of PC.

Analyses of optical microscopy were performed on layers of glass, as shown in Figures 2 and 3. Figure 2 is a magnification of 100x rear glass layer, where the TFT layer was observed, which is responsible for passing or not of light by the varying the applied voltage. Figure 3 is a magnification of 100x layer glass front, where was observed a set of pixels forming the image. Since each pixel is composed of three "subpixels", green, blue and red.



Figure 2 – Image of the rear glass layer of an LCD screen showing TFT layer

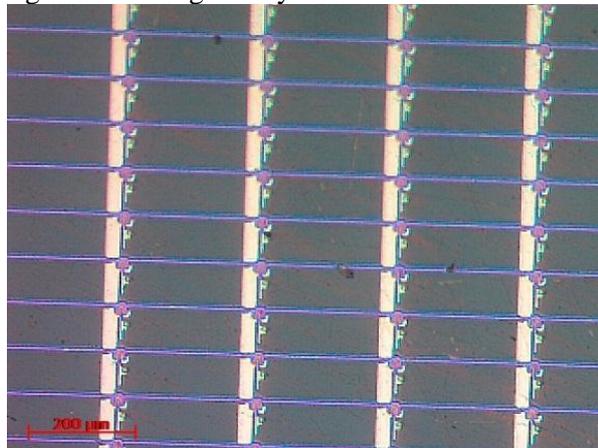
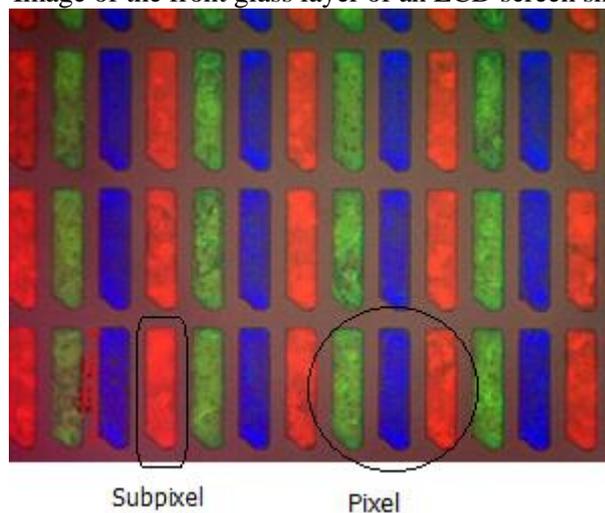


Figure 3 – Image of the front glass layer of an LCD screen showing pixels



The SEM / EDS analyses were performed on layers of glass to confirm the presence of the elements indium and tin, besides the material making up the layer of TFT. Figure 4 shows the front screen, confirming the presence of indium and tin and Figure 5 shows the rear screen, being a detailed picture of the TFT and the other picture an image magnification. Point 3 shows the circuits where the current pass, that are made of copper.



Figure 4 – SEM / EDS of the LCD screen - front layer

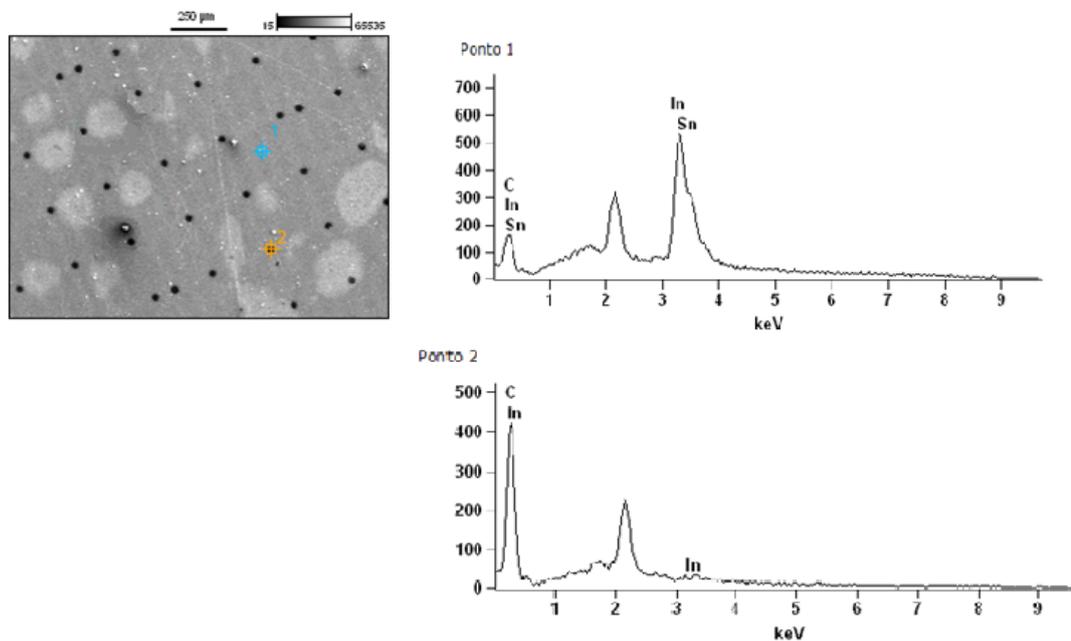
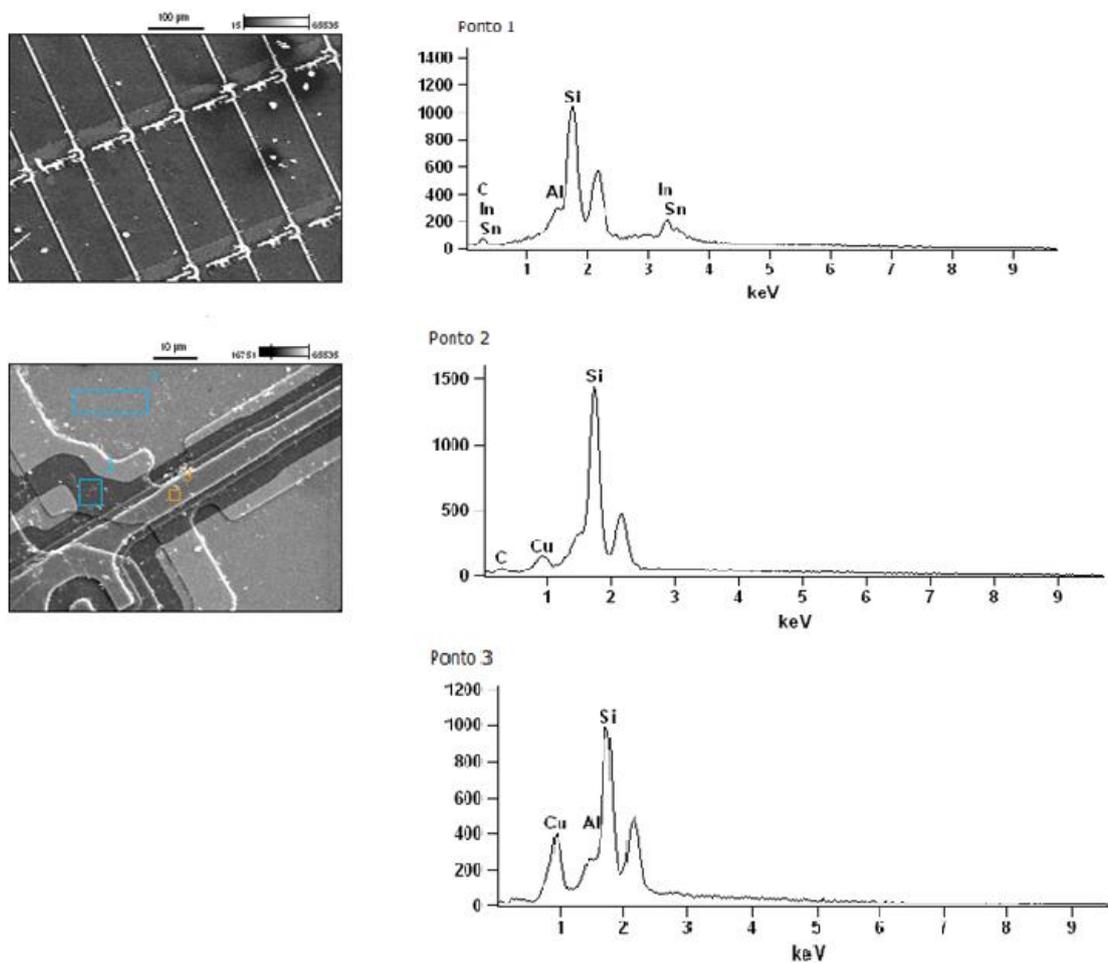


Figura 5 – SEM / EDS of the LCD screen - rear layer





To characterize the other constituents present in the LCD monitor, IR analysis were performed. Table 2 shows the preliminary results of samples:

Table 2 – Results of IR analysis

Structure	Material
Reflective sheet	Polyethylene terephthalate
Perspex	Styrene Acrylic
Diffuser sheet 3	Polymethyl methacrylate and methacrylic acid
Diffuser sheet 2	Polyester
Diffuser sheet 1	Methyl methacrylate
Polymeric layer (a)	Polyvinyl alcohol
Polymeric layer (b)	Poly (butyl acrylate)
Polymeric layer (c)	Cellulose ester

The found results for the polymeric films were equal for both layers on the glass.

4 Conclusions

After preliminary analyses show that LCD monitors has structures very similar to each other regardless of manufacturer, screen size and year of manufacture. While much of the constituents of the monitor can be recycled, some care must be taken.

Through this work was possible observe that, in general, the external frames of the monitors are thermoplastic polymers (PC, ABS and PMMA) and the LCD screen has polymer layers of different types (Table 2), addition of layers of glass containing indium, tin and copper mainly. Also constitute monitors, fluorescent lamps, PCB, cables and metal parts.

It is expected that over the next years, occurs an increase of the generation of this type of scrap, so there will be an increased generation of fluorescent tubes and printed circuit boards that are potentially hazardous materials due to the presence of mercury and heavy metals respectively. There will also be the generation of various types of polymers, glass and metals that can be recycled despite the complex mixture as found –be a complicating to the process.

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