COMPLETED PROJECT

Beneficiation of Flat Panel Functional Coatings

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INTRODUCTION

Flat panel displays (FPDs) are the predominant technology for televisions, computers, microdisplays, medical devices, and industrial instruments. Plasma display panels (PDPs) have begun to become more prominent in the FPD industry due to the increase in high definition technology. PDPs contain valuable constituents such as critical materials that industry leaders would like to recycle if it were economically feasible. The materials of interest are indium and rare earths.

The indium is present in the panel as indium tin oxide (ITO). The ITO is used as a transparent electrode on the surface of the front glass substrate. The amount of ITO in a panel depends on the panel size, but there is approximately 0.5 grams of ITO in a 44-inch panel. The potential steps for indium recovery include removal of the ITO from the glass substrate, recovery of indium from the ITO, and purification of indium.

The rare earth material is contained in the phosphors used to create color on the display. The rare earths present in the phosphors are yttrium, terbium, europium, and gadolinium. The phosphor coating is white and has been deposited onto the back glass substrate. The main problem with recovering rare earth elements (REEs) is removing the phosphor coating from the glass substrate and then recovering the rare earths from the phosphors. A lead solder was used to hold the phosphors together in some of the manufacturers' panels. The lead contained in the solder could cause health and safety issues as well as contamination issues during processing.

In order to access the various valuable materials in the PDP, the panel will have to be delaminated or cut apart. The two glass panels are adhered with a low melting glass frit. The glass panels not only need to be separated from each other, but the valuable materials need to be extracted and recovered from each of the glass panels.

OBJECTIVES

The objectives of this research program were to evaluate and develop innovative PDP recycling technologies. The five project tasks to be evaluated by this research program were as follows:

- Separation of glass panels through thermal delamination or cutting
- Removal of ITO thin film from front glass
- Removal of rare earth phosphors from back glass
- Recovery of indium from ITO thin film
- Recovery of REEs from rare earth phosphors

METHODOLOGY

Preceding the recycling technologies was an economic evaluation on the recoverable materials from PDPs. The methodologies used to evaluate the five project tasks were as follows:

- Thermal delamination of the glass panels was conducted in a tube furnace
- Leaching experiments were conducted on stock ITO powder and then on the front glass for ITO thin film removal from the front glass
- Leaching experiments were conducted on phosphor powder and then on the back glass for rare earth phosphor removal from the back glass
  - Physical separation was attempted after chemical treatment
- Leaching experiments were conducted on a feed of both the front and back glass for simultaneous ITO and rare earth phosphor removal
- Precipitation experiments were conducted to recover indium hydroxide from leach solutions
- Precipitation experiments were conducted to recover rare earth oxalates from leach solutions
- Two-stage precipitation experiments were conducted on the combined leach solutions.

OUTCOMES

An initial value assessment was conducted to determine the potential value available in a PDP. The estimated value in a 44inch PDP is around $0.91 depending on the value of indium and the REEs. There is also added value in the metal frame on the PDP. If stainless steel is used, the value jumps up to almost $21 per 44inch PDP. If an aluminum frame was used, then the value is closer to $7 or $8 per 44inch PDP.

Thermal treatment was unsuccessful in separating the glass panels. After multiple experiments, thermal delamination was removed from the process flow sheet. It is recommended that a cutting or crushing method be used instead.

Thin film leaching tests showed that the ITO thin film could be removed from the front glass through chemical treatment using sulfuric acid at an elevated temperature. Indium is dissolved into solution during ITO thin film removal. 99% of Indium was recovered during leaching experiments on stock ITO powder. The indium extracted during front glass leaching was 95%, but cannot be confirmed as accurate due to difficulties in chemical analysis.

Leaching of the PDP back glass showed that the rare earth phosphor thin film could be removed through the use of sulfuric acid at elevated temperatures followed by physical abrasion. 99% of REEs were extracted during powder leaches and 75% were extracted from the back glass leaches.

Simultaneous leaching of the front and back glass showed promise for both ITO thin film removal and rare earth phosphor removal. Indium extraction from the front glass was 95% and REE extraction from the back glass was 80%.

Precipitation testing on ITO leach solution successfully recovered 97% of the available indium as a hydroxide.

Precipitation testing on rare earth phosphor leach solution successfully recovered 98% of the available REEs in solution as oxalates.

The two stage precipitation on combined leach solution requires more investigation. 99% of the indium was recovered during the first stage when the indium concentration was high, but 23% of the REEs also precipitated out of solution. 65% of the REEs were recovered during the second stage.

DELIVERABLES

A M.S. thesis will be provided along with a review of the technical and patent literature on PDP recycling. Potential process flow sheets for industrial practice will be provided with a full economic analysis of each process method. Bi-annual presentations were also be provided to update committee members and member companies.

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