# Seminar

# Institute for Plasma Research

**Title :** A novel approach for processing waste printed circuit Boards

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**Time :** 03.30 PM

**Venue :** Committee Room 3, (New Building), IPR

**Abstract :**

Electronic waste (e-waste) from mobile phones, computers, TVs, laptops, tablet etc. is among the fastest growing waste streams in the world today. In addition to a variety of metals, ceramics and polymers, e-waste contains significant amounts of hazardous/toxic components as well. Both formal and informal sectors are engaged worldwide in recycling e-waste to recover precious and other metals (Hagelüken, 2006). Open burning of printed circuit boards (PCBs), plastic chipping and melting, burning wires to recover copper, acid & cyanide salt leaching, and inadequate metallurgical treatments are some of the poor recycling techniques used, especially in developing countries (Steiner, 2004; Wong et al., 2007). These inadequate practices can generate high levels of environmental pollution that affect both the ecosystems and the people living near the recycling areas (Jain & Sareen, 2006). The environmental fate of fumes, ashes and particles by burning activities is similar to that of dismantling dust, with toxic pollutants such as dioxins, furans and lead ending up in soil, ground water and atmosphere (Widmer et al., 2005). During controlled pyrolysis of waste PCBs in argon atmosphere in the temperature range 750-1550°C, it was observed that more than ~90% of lead present was lost as emissions during heating to 750°C (Rajarao et al., 2013); several other metals showed a similar trend. Loss of hazardous and other metals as emissions is a serious issue, especially during uncontrolled/open burning of waste, causing significant environmental pollution. The environmental fate of fumes, ashes and particles by burning activities is similar to that of dismantling dust, with toxic pollutants such as hazardous metals, dioxins and furans ending up in soil, ground water and atmosphere. To capture harmful emissions, extensive gas cleaning systems/filters have become integral components of waste management in developed countries; these are however rarely used in the informal sector or in developing countries due to cost factors and inadequate legislation.

This study is focussed on determining the nature of these emissions, to be used as an essential criterion for establishing environmentally safe practices for processing and managing ewaste. We report an in-depth investigation on emissions during high temperature pyrolysis of waste PCBs from mobile phones. PCBs were collected from a mixed collection of end-of-life mobile phones. Thermogravimetric analysis on these materials were carried out in the temperature range 30-800 °C. Maximum weight loss (up to 20%) occurred in the temperature range 300-400°C with gradual losses at higher temperatures. This weight loss is attributed to the degradation of polymers as well as the vaporization of organic constituents and volatile metals. Using TG-MS investigations in He atmosphere, emissions were also recorded online during continuous heating to 800 °C. In an another study, the PCB specimens were kept at 600 °C in a horizontal tube furnace using air, N2 and Ar

atmospheres, and the gases emitted were collected through a gas condenser and then dissolved in dimethyl sulfoxide (DMSO). These were later characterized using Gas chromatography/Mass spectroscopy (GC-MS) analysis. Phenol, 2-bromo was present in case of all four gases.

In another study, we present a novel approach to capture some of the toxic gases emitted during the heat treatment of e-waste using a range of adsorbents. In order to capture these gaseous constituents, the PCB powders were kept in between adsorbents (alumina, silica, zeolite, calcium carbonate, activated carbon etc.) in a quartz tube, and heated to 600 °C (heating rate 10 °C/min) in air and nitrogen and argon atmosphere for times ranging between 10 and 30 minutes. Weight gains up to 30% were recorded in some cases representing significant amounts of materials captured by adsorbents; silica gel showed one of the best performances.

Furthermore, a multistep process for recovery of pure copper from WPCBs was employed. The feed used in this study was the metallic residue obtained after plasma heat treatment of e-waste at 1400-1600 °C followed by acid leaching, which resulted in recovering nearly 56 % pure Cu metal. The benefit of plasma heat treatment of e-waste is to minimize production effluent harmful gases as compared to conventional pyrolysis method. The analysis of the acid leached plasma treated feed material by inductively couple plasma-optical emission spectrometry (ICP-OES).Further purification of the acid leached powder was primarily aimed at removal of toxic metals like tin and lead. These low melting metals along with zinc were removed by gradual heating of the metallic residue starting from 250 °C upto 950 °C. The remaining metal powder was melted at 1250°C in Muffle furnace having accuracy ± 5°C to obtain solid metal which is used for the copper extraction through electro-deposition process having the anode as crude metal and cathode as pure copper strip in copper sulfate as an electrolyte. Furthermore, the efficiency of Copper electrodeposition with respect to varying voltage and temperature was studied the material obtained after electrorefining comprised of (>99 %) Cu purity. The chemical analysis revealed traces of Pb, Sn and Zn in the pure copper fraction. This study provided a methodology for selective recovery of high purity copper from a feed of 20 g scale of waste printed circuit board.

The key challenge is to develop a robust, environmentally sustainable e-waste recycling process that can be implemented in developing and transitional economies in a cost-effective and energyefficient manner. Innovative approach presented in this study is expected to reduce emissions towards environmentally safe limits through capture of volatiles/particulates consistent with excellent material recovery and waste recycling.

REFERENCES

Hagelüken, C. 2006. Improving metal returns and eco-efficiency in electronics recycling - A holistic approach for interface optimisation between pre-processing and integrated metals smelting and refining. IEEE International Symposium on Electronics and the Environment, San Francisco, California USA, 218-223.
Jain, A., Sareen, R. (2006). E-waste assessment methodology and validation in India. J. Mater. Cycles Waste Manage., vol. 8, n. 1, 40-45.
Steiner, S. (2004). Risk assessment of e-waste burning in Delhi, India. Federal Institute of Technology ETH, Zurich.
Widmer, R., Oswald-Krapf, H., Sinha-Khetriwal, D., Schnellmann, M., Böni, H. (2005). Global perspectives on e-waste. Environ. Impact Asses., vol. 25, n. 5, 436-458.
Wong, M. H., Wu, S.C., Deng, W.J., Yu, X.Z., Luo, Q., Leung, A.O.W., Wong, C.S.C., Luksemburg, W.J., Wong, A.S. (2007). Export of toxic chemicals – A review of the case of uncontrolled electronic-waste recycling. Environ. Pollut., vol. 149, n. 2, 131-140.
Rajarao, R., Sahajwalla, V., Cayumil, R., and Khanna, R. (2013)Novel approach for processing hazardous electronic waste. Procedia Environmental Sciences ed. L. Beesley Vol. 21, pp. 33- 41/Urban Environmental Pollution Conference Proceedings China.