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Usability of wood-based materials as a supporting layer of PCB

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Abstract: *Usability of wood-based materials as a supporting layer of PCB.* The paper describes materials used for printed circuit boards (PCB). Major problems faced during the process of recycling of wastes from electronic equipment containing PCBs are discussed. At the present time, more than 70% of the total bulk of recovered wastes undergoes utilisation and only 30% is recycled. Therefore, it has been proposed to replace laminates widely used as carrier materials in PCBs by biodegradable wood-derived materials. Significant wood structural properties were compared with those of the currently applied materials. In conclusions, advantages and disadvantages of wood-derived materials used in electronic equipment were collated.

Keywords: PCB, recycling technology, wood based PCB

INTRODUCTION

A printed circuit board (PCB), is widely used to mechanically support and electrically connect electronic and electromechanical components. Basic structural elements of PCBs are: conductive pathways, tracks or signal traces etched from metal sheets laminated onto a non-conductive substrate. The circuits in PCB are formed by a thin layer of conducting material deposited, or "printed", on the surface of an insulating board known as the substrate. Electronic components are soldered to the interconnecting circuits (two technologies are used: traditional THT - Through-Hole Technology and more modern SMD - Surface Mount Device) [6].

Printed circuit boards were invented in the 1940s, modern PCBs were introduced in the 1970s, and till now are commonly used. In contemporary PCBs conducting layers are typically made of thin copper foil. Insulating layers dielectric are typically laminated together with a glass fiber reinforced (fiberglass) epoxy resin. The board is usually coated with a green solder mask (blue and red colors of solder mask are available too).

Large quantities of nonmetals in PCBs (up to 70%) are a major challenge for recycling [1]. Nonmetals of PCBs generally consist of thermoset resins and reinforcing materials which are incompatible in the recycling processes. Thermoset resins cannot be remelted or reformed due to their network structure. Incineration is not the best method for treating nonmetals because of inorganic fillers such as glass fiber, which significantly decrease the fuel efficiency. In addition, the combustion of electronic waste in the presence of copper from PCBs may lead to higher emissions of polychlorinated dibenzo-para-dioxins (PCDDs) and dibenzofurans (PCDFs) into the environment, causing even worse environmental pollution [3].

PCBs AND THE ENVIRONMENT

Each product, to a smaller or greater extent, exerts a negative impact on the environment. Life-cycle of the majority of contemporary products is long and complex and this also refers to PCBs. This period includes, among others, phases of product design, technology elaboration, raw material preparation, manufacturing, distribution, and utilisation, repair, recycling and rendering the products harmless. The designing phase of each product appears to exert a key role with regard to its future onerousness for the environment as it is the designer who decides, among others, about the energy consumption of the product as well as its future recyclability.

Design for environment (DfE) is a designing philosophy in which special emphasis is placed on the reduction of noxious effects on the environment exerted by industrial products in the course of all stages of the product life-cycle. Forward planning of recycling possibilities in the early stage of product design increases considerably the percentage proportion of materials recoverable as a result of waste recycling.

According to DfE principles, products must be designed in such a way as to increase in them quantities of materials suitable for recycling and to expand the use of raw materials derived from recycling (the so called 'recyclates'). When 'designing for recycling', it is essential to constantly bear in mind the principle of the reduction of diversity of material used in the product. In particular, it is not advisable to employ materials incompatible in recycling where one of the constituent contaminates recyclates.

PCBs production and utilisation are quite onerous for the environment [1]. Wet chemical processes widely employed in these processes devour considerable quantities of water and energy and require application of chemical compounds which constitute potential hazards for human health and environment.

Contemporary technologies employed in the recycling and utilisation of PCBs can be divided into two groups: thermal technologies of the type of pyrolysis, hydro-metallurgy and metallurgy as well as non-thermal technologies such as: disassemble, disintegration, separation and chemical treatment mentioned earlier [2]. Application of wooden PCBs allows employment of a completely new method – low energy-consuming and safe biological method, in other words, it allows application of fungi or microorganisms to degrade electronic wastes. Cheap biological utilisation of the wood carrier layer facilitates subsequent separation of the remaining substances (metals, small quantities of ceramics and plastics).

PCBS MADE FROM WOOD

Electrical properties of wood-derived materials do not differ significantly from the identical properties of typical laminates manufactured from epoxy or phenolic resins traditionally applied in electronics (Tab. 1).

Table 1. Chosen properties of boards materials (based on [4], [5], [6])

Material	Reinforcement	Matrix	Approximate prices (in comparison to FR4)	Max. long-term operating temperature	Permittivity	Loss tangent
FR1/ FR2	Paper	Phenolic resin	0,2-0,3	70° C	4,25	0,05
FR3	Paper	Epoxy resin	0,5-0,6	90° C	no data	0,041
CEM1	Paper	Epoxy resin	0,7-0,8	no data	no data	0.031
CEM3	fibreglass	Epoxy resin	0,80-0,85	no data	no data	no data
Plywood	Cellulose fibbers	lignin	0,15-0,20	120° C	2,0-8,0	0,054
HDF	Cellulose fibbers	lignin	0,04-0,05	130° C	3,0-6,0	0,04
FR4	fibreglass	Di / Tetra-epoxy resin	1	115-180° C	3.8-4.5	0,019
FR5	fibreglass	Tetra / Multi-epoxy resin	1,4-1,6	140-175° C	no data	0,016
FR5 BT	fibreglass	BT- epoxy resin	3	no data	no data	0,015
Poliimide	fibreglass	Polyimide	3,0-4,4	230-260 ° C	no data	no data

Careful analysis of Table 1 shows that specificity of wood-derived boards cause that their individual electrical properties are contained within wide boundaries. Plywood and HDF are characterised by layered structure. Similarly to other materials containing fibrous fillers, especially those of layered structure, they are characterised by anisotropy of relative electric permittivity and of loss tangent coefficient. The scatter of the above properties can be attributed to two causes. Different layers of plywood or HDF board can have different material parameter values. Individual layers in board wood-derived materials, due to poor homogeneity, are characterised by heterogenous volume structure.

Moreover, electric permittivity and loss tangent coefficient of dielectric materials also depend on temperature, intensity of electric field and moisture content as well as on the frequency of the electromagnetic field. The above properties change together with aging of the material [5].

SUMMARY

Advantages of the application of wood derived materials for PCBs include:

- Nontoxicity,
- Recyclability, especially to biological degradability,
- Lower energy consumption during machining, e.g. lower ducking of drills,
- Good electrical parameters,
- Smaller specific gravity.

Potential disadvantages include:

- Poorer heat removal from mounted elements,
- Hygroscopicity and dimensional changeability connected with it,
- Changeability of construction properties in time.

Nevertheless, despite these shortcomings, wood-derived materials constitute a promising material for PCBs.

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Streszczenie: *Przydatność tworzyw drzewnych jako warstwy nośnej płytek PCB.* W artykule opisano materiały stosowane na elektroniczne płytki drukowane (PCB). Wskazano podstawowe problemy w trakcie recylingu odpadów z urządzeń elektronicznych zawierających PCB. Obecnie ponad 70% masy pozyskiwanych odpadów podlega utylizacji, a jedynie 30% ponownemu przetworzeniu. W związku z powyższym zamiast powszechnie stosowanych laminatów zaproponowano biodegradowalne tworzywa drzewne jako materiał nośny płytek PCB. Porównano istotne właściwości konstrukcyjne drewna z analogicznymi właściwościami dotychczas stosowanych tworzyw. W podsumowaniu zestawiono wady i zalety tworzyw drzewnych w zastosowaniach elektronicznych.

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