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Effect of High-Humidity Testing on Material Parameters of Flexible Printed Circuit Board Materials

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The tendency of polymers to absorb moisture impairs especially their electrical and mechanical properties. These are important characteristics for printed circuit board (PCB) materials, which should provide mechanical support as well as electrical insulation in many different environments in order to guarantee safe operation for electrical devices. Moreover, the effects of moisture are accelerated at increased temperatures. In this study, three flexible PCB dielectric materials, namely polyimide (PI), fluorinated ethylene-propylene (FEP), and polyethylene terephthalate (PET), were aged over different periods of time in a high-humidity test, in which the temperature was 85°C and relative humidity 85%. After aging, the changes in the structure of the polymers were studied by determining different material parameters such as modulus of elasticity, glass-transition temperature, melting point, coefficient of thermal expansion, water absorption, and crystallinity, and changes in the chemical structure with several techniques including thermomechanical analysis, differential scanning calorimetry, Fourier-transform infrared spectroscopy, moisture analysis, and a precision scale. The results showed that PI was extremely stable under the aging conditions and therefore an excellent choice for electrical applications under harsh conditions. Similarly, FEP proved to be relatively stable under the applied aging conditions. However, its crystallinity increased markedly during aging, and after 6000 h of aging the results indicated oxidation. PET suffered from hydrolysis during the test, leading to its embrittlement after 2000 h of aging.

Key words: Aging, high humidity, flexible PCB dielectric film, oxidation, crystallinity

INTRODUCTION

Printed circuit boards (PCBs) are essential parts of electrical devices. They consist of one or more dielectric layers onto which conductive traces have been patterned. The most common materials for PCB dielectrics are fiber-reinforced epoxies, but flexible thermoplastics can also be applied. PCBs provide electrical connectivity and mechanical support for components mounted on them. Additionally, they provide a safe working environment for the whole device, including a path for thermal conduction away from components.[1,2]

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The trend towards portable electronic devices has increased the demand for flexible PCBs, as they enable lower weight, smaller and thinner packages, as well as improved vibration resistance.[3] Flexible PCB materials typically refer to the set of conductive and insulating materials used in flexible interconnect boards: dielectric films, adhesives, wiring, and cover layers.[4] An example of a typical flexible PCB is shown in Fig. 1. It has been reported that the presence of the metal wiring decreases the moisture diffusion into the PCB and additionally hinders the egress of moisture during drying.[5,6] However, this study concerns only the properties and behavior of dielectric films for flexible PCBs. The specific aim is to study how these properties change in harsh environments. In addition to