DIELECTRIC MATERIAL

Edited by **Marius Alexandru Silaghi**

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Preface

This book attempts to bring together the theory and practice of dielectric materials for different kind of industrial applications.

Fragmented information on dielectric theory and properties of materials, design of equipment and state of the art in applications relevant to the manufacturing industry should be collated and updated and presented as a single reference volume.

In this book relevant and useful information is presented in the quoted literature and covered by our key patent applications.

As an Editor and also Author in this field, I am honored to edit this book written by a selected group of researchers.

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Section 1

Polymeric Dielectric Materials

Chapter 1

Polymeric Dielectric Materials

Zulkifli Ahmad

Additional information is available at the end of the chapter

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1. Introduction

1.1. Background and brief history

The definition for dielectric constant relates to the permittivity of the material (symbol use here ε). The permittivity expresses the ability of a material to polarise in response to an applied field. It is the ratio of the permittivity of the dielectric to the permittivity of a vacuum. Physically it means the greater the polarisation developed by a material in an applied field of given strength, the greater the dielectric constant will be. Traditionally dielectric materials are made from inorganic substances eg. mica and silicon dioxide. However polymers are gaining wider use as dielectric materials. This is due to the easier processing, flexibility, able to tailor made for specific uses and better resistance to chemical attack. As early as mid-60's polymers eg polyvinyl fluoride [1] and aromatic-containing polymers [2] are used as dielectric materials in capacitors. Further improvement in organic film fabrication was established as revealed in US Patent 4153925. Polymers can be fabricated fairly easily into thin film by solution casting and spin coating, immersion in organic substrate, electron or UV radiation and glow discharge methods. This is mainly due to lower thermal properties such as glass transition and melting temperature which contribute to a lower temperature processing windows. Their solubility is controllable without offsetting their intrinsic properties. In the case of inorganic material and ceramic, they have much higher thermal properties hence temperature requirement leads to an extreme end of processing temperatures. On the other hand polymers cannot stand too high a temperature. Their coefficient of thermal expansion is relatively larger than ceramic materials and susceptible to atmospheric and hydrolytic degradation. Table 1 shows the values of dielectric properties of several polymers with comparisons with several inorganic materials.

Inorganic/ceramics materials have higher dielectric constant than polymers. Water has a relatively high dielectric constant. This is quite cumbersome as any traces of moisture trapped or absorb will dramatically alter the desired dielectric properties. Inorganic materials generally have higher dielectric constant compared to polymeric materials. Intrinsically they contains ions and polar groups which contribute to their high dielectric constant. Air having a dielectric constant of 1.02 is taken as reference dielectric.

Materials	Dielectric constant, ε	Materials	Dielectric constant, ε
TiO_2	100	Fluorinated polyimide	2.5 – 2.9
H_2O	78	Methylsilsesquioxane	2.6 – 2.8
neoprene	9.8	Polyarelene ether	2.8 – 2.9
PVDF	6.0	Polyethylene	2.3 – 2.7
SiO2	3.9 – 4.5	Polystyrene	2.5 – 2.9
Fluorosilicate glass	3.2 – 4.0	Teflon AF	2.1
Polyimide	2.8 – 3.2	Air	1.02

Table 1. Dielectric constant of several polymers and inorganic materials. (Adapted from Ref 3)

1.2. Application of polymeric dielectric materials.

Both dielectrics with low and high dielectric constant are essential in electronic industries. Low dielectric constant is required basically as insulators. They are known as passivation materials. Their applications ranged in isolating signal-carrying conductors from each other, fast signal propagation, interlayer dielectric to reduce the resistance-capacitance (RC) time delays, crosstalk and power dissipation in the high density and high speed integration [4]. They are of necessity in very dense multi-layered IC's, wherein coupling between very close metal lines need to be suppressed to prevent degradation in device performance. This role involve packaging and encapsulation. In electronic packaging, they separate interlayers and provide isolated pathways for electronic devices connection in multilayer printed circuit boards. As the trends are towards miniaturization in microprocessor fabrication, any decrease in relative permittivity will reduces the deleterious effect of stray and coupling capacitances. Dielectric naterials are also employed to encapsulate the balls which bridged the die and substrate. This encapsulation is specifically called underfill which helps to protect any circuitary failures as well as reducing thermal mismatch between the bridging layers.(Figure 1) In LED encapsulation low dielectric materials is used for insulation at the lead frame housing.

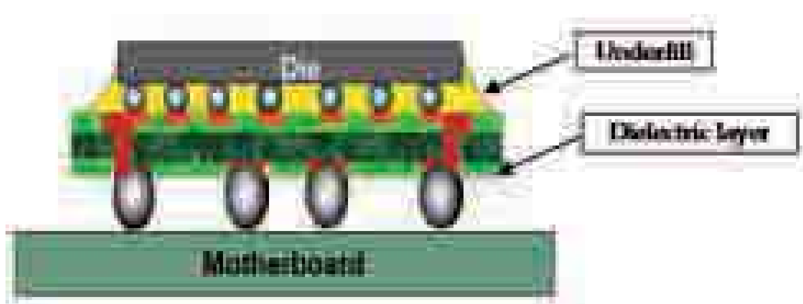

Figure 1. Application of dielectric polymers in IC packaging