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Integrated circuits protection with the Langmuir–Blodgett Films

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Abstract

Integrated circuits (ICs) can be protected from the environment with the encapsulating polymer layer. Protection properties of such a polymer barrier-layer depend strongly from the structure of thin region where polymer stays in direct contact with the IC surface. One of the interesting questions is how thick should this interphase film be to assure good environmental protection to the IC conductor lines, preventing from their corrosion and failure. In order to answer this question a set of electronic testers with Al conductor lines were modified with 1, 20, 50 multilayers of stearic acid molecules deposited in the Langmuir–Blodgett (LB) transfer method. Next, the electronic testers were subjected to the highly accelerated aging conditions (100% relative humidity (RH), 100 °C) for a period of up to 800 h and conductor lines resistivity changes were monitored. Electronic testers modified with 20 multilayers of stearic acid were better protected from the accelerated aging conditions than the testers modified with 1 monolayer or 50 multilayers. Obtained results suggest that the thickness of the interphase region separating IC surface and polymeric film should be in the range of 10 nm.

Keywords: Encapsulation; IC protection; Interphase region; LB film; Passivation layer

1. Introduction

Electronic integrated circuits (ICs) can be protected from the environment with encapsulating polymeric layer. Encapsulating polymer had to fulfill several conditions—electrical and mechanical. Electrical properties like high resistivity, low content of ionic impurities and low dielectric constant value will be not discussed here. However, the mechanical properties, closely related with the polymer barrier protection like good adhesion to the substrate, low water uptake value, low permeability of water vapors and rheological properties, are closely related with the thickness of encapsulating polymer film. Thicker film does not always mean better environmental protection, its easier delamination, separation and loss of protection barrier properties can rather be expected. Similarly to the phenomena observed in the paint industry, coating applications, sensor film layer, composite materials, protection properties and good adhesion are closely related with the thin interphase layer separating two adhering materials (IC and encapsulating polymer). How thick should this layer be? Sometimes it is claimed that for good environmental protection, several monolayers or even one coupling monolayer thick film are enough to assure good adhesion and proper barrier properties [1–5]. Construction of thin film on the electrode surface, which can assure both environmental protection and proper electrical properties is an important question not only for the IC encapsulation but also for the sensors construction. How thick should the sensor active layer be? A too-thin layer can be easily delaminated or mechanically removed form the sensor's surface. A too-thick active layer can show unacceptable long delay in the electrochemical response or can be too insensitive to the variations of studied species concentration. One can

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Table 1
The electrochemical parameters of cyclic voltammogram of free and modified MB in 0.1 M phosphate buffer solution (pH 7.0) at scan rate of 35 mV/s

	E_{pc} (V)	E_{pa} (V)	$E^{\circ\prime}$(V) (vs. Ag/AgCl)	ΔE (V)	Γ (mol cm^{-2})
In solution[a]					
MB	−0.219	−0.191	−0.205	0.028	–
MB+DNA	−0.226	−0.191	−0.209	0.035	–
In membrane[b]					
DNA–MB/PAA/AuE	−0.248	−0.212	−0.230	0.036	2.78×10^{-10}
HRP/DNA–MB/PAA/AuE	−0.247	−0.204	−0.226	0.043	2.10×10^{-10}

[a] In this case, 0.1 mM methylene blue, 0.2 mg/ml DNA and 0.2 mg/ml HRP were used.
[b] The membrane prepared by using 2 mg/ml DNA, 0.2 mM methylene blue, 1 mg/ml HRP and 1 mg/ml PAA.

also expect that better environment protection means also better chemical (or electrochemical) stability. In this paper, we have decided to test how thick should be the thin film deposited in the Langmuir–Blodgett (LB) transfer method to protect Al conductor lines from the corrosion developed during the accelerated aging conditions (Table 1).

2. Experimental

Electronic testers "Tester 5 PW ITE" mimicking real Integrated Circuits (Fig. 1) were mounted in standard DIP-40 package.

Each tester had several triple-track testers, each one with three meandering Al conductor lines (structures: TT3, TT7,

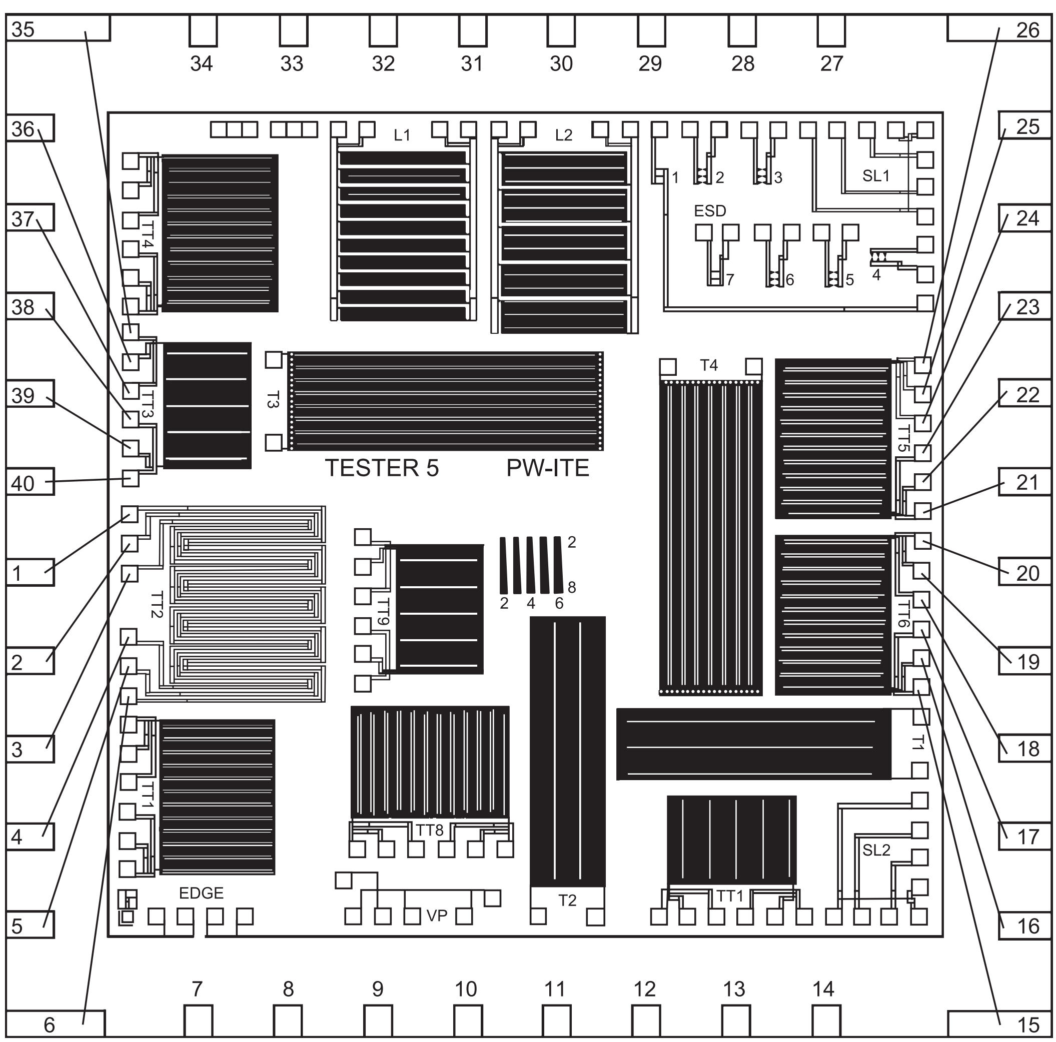

Fig. 1. Electronic tester "Tester 5 PW ITE" made on 6260×6260 μm Si chip with Al metallization.