Measuring Electrical Materials Properties Using Microfabricated Interdigitated Microsensor Electrodes (IMEs) and Independently Addressable Microband Electrodes (IAMEs).

An ABTECH Application Note

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I. INTRODUCTION

The measurement of electrical materials properties of organic thin films, while generally a simple laboratory procedure, nonetheless requires careful design and consideration if the results obtained are to be converted into a characteristic material property. The resistance of an organic thin film fabricated as a fully contiguous layer that spans the electrodes or covers the functional area of interdigitation of an IME device is described.

Cleaning procedures and surface activation procedures are summarized in IME Application Note (clean0498.pdf) for interdigitated microsensor electrodes (IMEs), planar metal electrodes (PMEs), independently addressable microband electrodes (IAMEs), and co-planar electrochemical "cell-on-a-chip".

Table 1. SENSOR CELL CONSTANTS

Device Designation	Plan Area Cell Constant K (cm^2)	Sheet Resistance Cell Constant □	l / 3 (mm)	Zaretsky Cell Constant (cm^{-1})
IME 0550.5	0.0250	100100	6.6	0.04
IME 1050.5	0.0501	50100	13.3	0.04
IME 1550.5	0.0752	33433.33	20	0.04
HRL IME 2550.635	0.1594	25500	33.3	0.03
IME 1010.3	0.0060	6020	13.3	0.34
IME 0525.3	7.51×10^{-3}	30050	6.6	0.13
IME 1025.3	1.51×10^{-2}	15050	13.3	0.13
IME 1525.3	2.26×10^{-2}	10050	20	0.13
IME 2025.3	0.0302	7550	26.7	0.13

IME = Interdigitated Microsensor Electrode.

Table 1 above gives a list of the Zaretsky cell constants of the several chip designs available from ABTECH Scientific, Inc.

1. The Zaretsky[1] convention defines the meander length, M = N•d, where d is the digit length (μm) and N is the number of digit pairs that form the array. The center line or serpentine length S (cm) = 2 M. The digit width, a (μm), and interdigit space, a′ (μm), are for most ABTECH devices equal. The spatial periodicity or lattice constant is, for equal line and space dimensions (i.e. a = a′), defined as λ (μm) = 2a + 2a′ = 4a. G* = G/σM = 1/kM, where k is the cell constant[2]. For equal lines and spaces G* = 1 and hence kM =1. Then k = 1/M (cm^{-1}). The dimensional or cell constant of the ABTECH IME chips is therefore defined as the reciprocal of the meander length.

2. To obtain the **resistivity**, ρ, of an organic thin film: first, measure the two-point or four-point resistance of the fully contiguous film on the digits of the device. Secondly, devide the measured resistance by the device cell constant (Ohm cm, Ω cm).

3. To obtain the **conductivity**, σ , of an organic thin film: first, measure the two-point or four-point resistance of the fully contiguous film on the digits of the device. Secondly, multiply the reciprocal of the measured resistance by the device cell constant (Ohm^{-1} cm^{-1}, Ω^{-1} cm^{-1}, mho cm^{-1} or S cm^{-1}).

4. To obtain a form of resistance normalization for device dimensions, divide the measured resistance in Ohms (Ω) by the plan area cell constant, **K,** to give Ohms/cm^2 (Ω/cm^2). This value has no fundamental significance whatever, except to allow for convenient discussion of sensor responses obtained form different device designs.

5. To obtain the sheet resistance in Ohms/square (Ω/□), multiply the measured resistance in Ohms (Ω) by the dimensionless cell constant, □. NOTE: This is for a parallel plate sensor model, known to be inappropriate for IMEs.

6. To obtain resistivity (the material property) in Ohm • cm (Ω • cm), multiply the sheet resistance in ohms/square (Ω/□) by the known or estimated thickness of the polymer film. NOTE: This is for a parallel plate sensor model, known to be inappropriate for IMEs.

IME XXYY - FD, CD or M - M - *P or U

where M = Au, Pt or ITO

XX = digit and space width (20, 15, 10 or 05 μm)

YY = number of lines per bus of the array (25, 50, 10)

DESIGN: M = Monolithic, CD = Combined Differential, FD = Full Differential

P: Packaged device; U : Un-packaged device

IV RERERENCES

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