UNIVERSITI TEKNOLOGI MARA

SIMULATION AND CHARACTERIZATION OF PZT THIN FILM CAPACITORS FOR MMIC APPLICATIONS

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Candidate's Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of University Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

In the event that my thesis be found to violate the conditions mentioned above, I voluntarily waive the right of conferment of my degree and agree to be subjected to the disciplinary rules and regulations of University Teknologi MARA.

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ABSTRACT

This thesis reports a research carried out to simulate and characterize lead zirconate titanate (PZT) thin film capacitors for monolithic microwave integrated circuit (MMIC) applications.

The PZT thin film capacitor was modeled as thin film microstrip structure (TFMS) which shares the same configurations as a conventional microstrip. The capacitor was simulated using electromagnetic simulator *Sonnet* to determine the important characteristics of 50 Ω line width, and PZT thickness and permittivity. For a 50 Ω line, the width obtained is merely 300 nm for a PZT of $\varepsilon_r = 100$. This results in size reduction of more than fifty times compared to conventional MMIC. Various capacitor areas were also simulated and the effects of parameters such as ε_r, d and A on the capacitance values were investigated. The capacitance is simulated for film thicknesses ranging from 0.1 to 0.3 μm and ε_r from 100 to 1000. The capacitor electrode areas were changed from 3×3 μm^2 to 50×50 μm^2 over the frequency range of 1 - 100 GHz.

In order to prove the feasibility of this new idea, capacitors utilizing PZT thin films were deposited on Pt/Ti/SiO_2-coated Si substrates. The films were grown by RF sputtering, and platinum and gold electrodes were delineated on the samples using electron beam lithography. For an electrode area of 50×50 μm^2, capacitance values of 10 pF were obtained at frequencies up to 20 GHz. Suitable de-embedding of S-parameters using *Cascade* microwave probes revealed films with ε_r of the order of 300 to 500.

To the author's knowledge this project constitutes the first work on PZT thin film capacitors for MMIC applications.

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CHAPTER 1

INTRODUCTION - RESEARCH FRAMEWORK

1.0 Introduction

This chapter provides an overview of the work involved in this research. It provides the background and gives the rationale for the study. A brief overview of microwave technology and its applications serves to give a basic understanding of microwaves. A discussion of the main issues and problems in current technology sets forth the rationale, significance and objectives that led to this research. The chapter ends with a description of the organization of this thesis.

1.1 A Brief Overview of Microwave Technology and Its Applications

The field of microwave engineering is receiving significant industrial attention due to its important role of improving lifestyle. People commonly associate this technology with the domestic oven. This results in the technology being mainly associated with cooking. However, in reality, it covers a bigger aspect in our lives.

The term 'microwave' refers to alternating current (ac) signals with frequency range between 300 MHz and 300 GHz [1]. Microwave is a part of electromagnetic spectrum as shown in Fig. 1.1.