CHAPTER 2

OBJECTIVES OF THE WORK

The innovations in materials research for understanding the development, use and control of the properties of low loss dielectric microwave ceramics has a great impact on the areas of environmental monitoring, global positioning system (GPS), internet of things (IoT), terrestrial and satellite communications. Low-loss dielectric oxide ceramics have revolutionized the wireless communication industry by reducing the size and cost of microwave devices and components.The advancing modern communication industry is searching for novel microwave dielectric materials with low sintering temperature, ultra-low dielectric loss, a low or matching coefficient of thermal expansion and appropriate dielectric properties. In order to meet the specifications of future systems, new materials and designs of microwave components are required. New technologies have particularly pushed the demand for low-loss dielectric materials.

For any material, after its preparation, it is important to identify its application in suitable areas. From material synthesis to final device fabrication, various steps need to be followed, involving two branches of engineering i.e. Ceramic Engineering and Electronics Engineering. It is important to design and develop microwave components with prepared materials using suitable software e.g. High Frequency Structure Simulator (HFSS) and available data on dielectric parameters. Once the optimum design is formulated, the device is to be fabricated and experimentally tested for its performance in comparison with the simulated parameters.

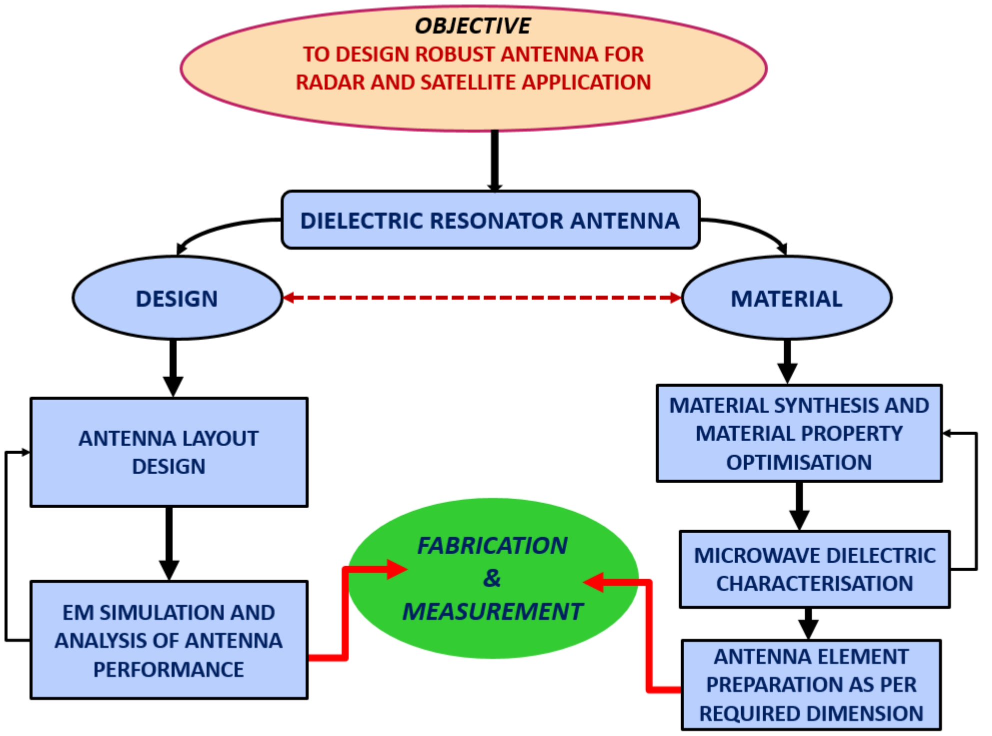

Figure 2.1 The material synthesis, antenna design and simulation work flow chart.

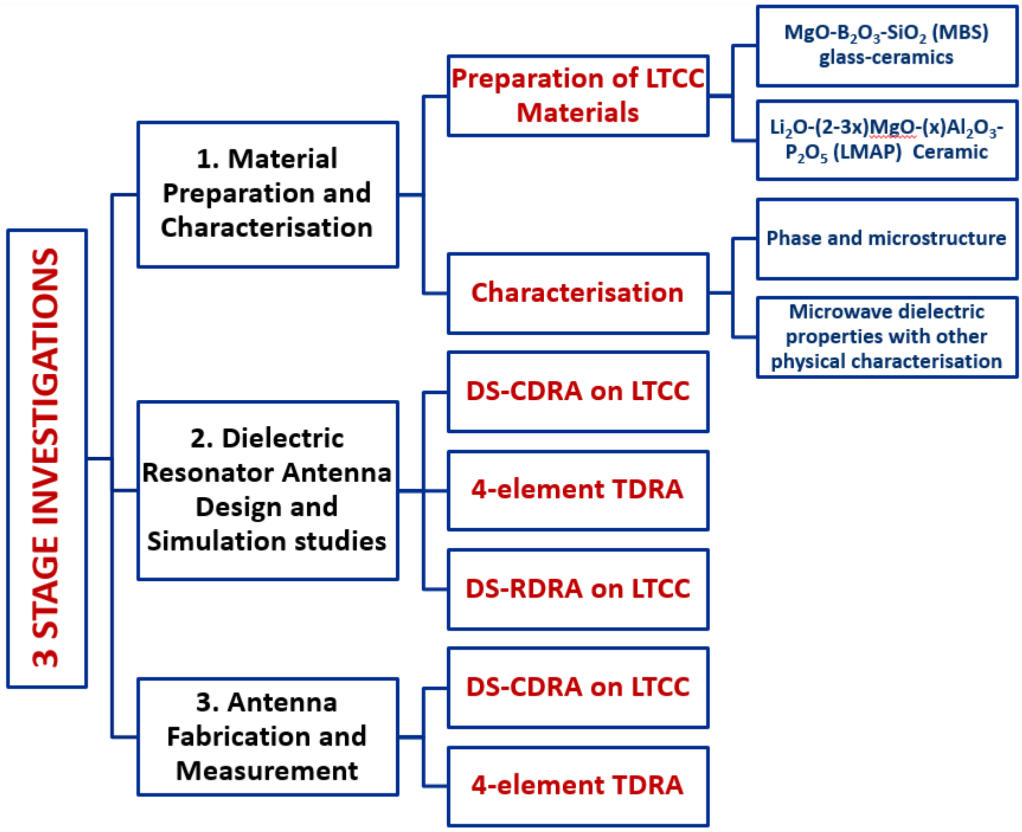

Figure 2.2 The objective of the work (Flow chart).

In the present investigation, the objective is to synthesize materials with low dielectric constant, low loss and characterize their microstructure and properties, which may be used as substrates or as resonating element for design and development of microwave dielectric resonator antennas. The investigation comprises of three stages:

2.1 Material preparation and characterization

2.2 Dielectric Resonator antenna design and simulation studies

2.3 Antenna fabrication and measurement

The detailed objectives of the present investigation are as follows:

2.1 Material Preparation and characterization

2.1.1 To formulate $MgO–B_2O_3–SiO_2$ (MBS) glass-ceramics having TiO_2 as nucleating agent for LTCC applications and to study the effect of TiO_2 addition on thermal and dielectric properties of MBS glass-ceramic;

2.1.2 To conduct detailed analysis of microstructural, phase, and densification behaviours as well as microwave dielectric properties of $Li_2O–(2\text{-}3x)MgO–(x)Al_2O_3–P_2O_5$ (LMAP) ceramics for optimizing Al_2O_3 concentration for LTCC application;

2.2 DRA design and simulation studies

It is planned to use MBS glass ceramics and LMAP ceramics possessing low sintering temperature with good microwave dielectric properties as substrate materials for the design of antennas. It is believed that utilizing the prepared material is a viable approach for LTCC substrate application in microwave devices. These materials with low loss can also be used as resonator element for the dielectric resonator antennas as well. Design of antenna using these materials was performed using Ansys High Frequency Structure Simulator (HFSS) software. Parametric study is carried out by varying different antenna parameters, such as probe height, and aperture dimensions, resonator dimensions, substrate dimension etc. Investigations for different types of antenna designs comprise the following:

2.2.1 To design a dual segment cylindrical DRA (DS–CDRA) on LMAP substrate which can provide broadside radiation pattern and good gain.

2.2.2 To design four element composite triangular DRA (TDRA) using LMAP ceramic for wideband application which provides monopole like radiation and good gain.

2.2.3 To design dual segment rectangular DRA (DS–RDRA) on MBS glass ceramic substrate.

2.3 Antenna fabrication and measurement

Fabrication of the following dielectric resonator antennas and measurement of antenna input and radiation characteristics were performed and experimental results are compared with the respective simulation results.

2.3.1 To fabricate DS–CDRA on LMAP substrate to provide broadside radiation pattern.

2.3.2 To fabricate four element composite TDRA using LMAP ceramic and teflon as radiating elements to provide wideband monopole like radiation.