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Dielectric materials research to curb mobile phone network issues

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Abstract
Signal attenuations, SMS jam, cross-talks etc. are some of the common issues of Telecommunication service. The entire system of mobile communication depends upon the proper functioning of both the materials (chemical aspect) as well as the mechanical (engineering aspect). The chemical aspect involves the production of dielectric ceramics and resonators. In this regard, complex perovskite ceramics have been extensively studied for their applications to dielectric resonators at microwave frequencies.

Keywords: Mobile phone hassles, Dielectric materials, Perovskites

Introduction

Today's world is the world of information and communication. Communication has a great power to bring about changes. It is one of the key parameter for businesses and progresses. Information Technology (IT) boom and the growth of mobile phone market in the last few decades created a feeding frenzy leading to an extensive research and developments in the area of wireless communications.

Mobile phone has become a basic need for everybody. Today it is time to say 'Good Bye Landline'. The demand of increasing competition for miniaturization of communication devices and quality services in the wireless communications among the national and multinational companies has compelled them to review and improve their mobile phone services.

As in the business world quality service is always in demand, Tele-Communication companies (TCs) have been facing challenge to cope with the quality of the transmitted/received frequency band. There are very frequent issues of signal attenuations, SMS jam, and cross-talks. The TCs might have made attempts to solve these service related problems in one and the other ways. But what is realized that TCs tends to curb the service to the common people time and often. This is not only an improper way of tackling with the problem but also against the customers' right.

As a matter of fact the entire system of mobile communication depends upon the proper functioning of both the materials (chemical aspect) as well as the mechanical (engineering aspect). Mobile Phone Networks allow communication from cell to cell *via* antennas located on masts and associated base stations. Each base station houses microwave(MW) resonators which are used to carry signals of a specific frequency and remove/filter spurious signals and side bands that interfere with the quality of the transmitted/received frequency band. Ceramic pucks suitable for resonator applications are designed to sustain a standing wave within its body of a specific resonant frequency and may therefore act as either a filter or a transmitting resonator. In service, the ceramic conventionally rests within a silver coated square cavity. Typically many hundreds of these cavities will reside in the base stations of a cellular network.

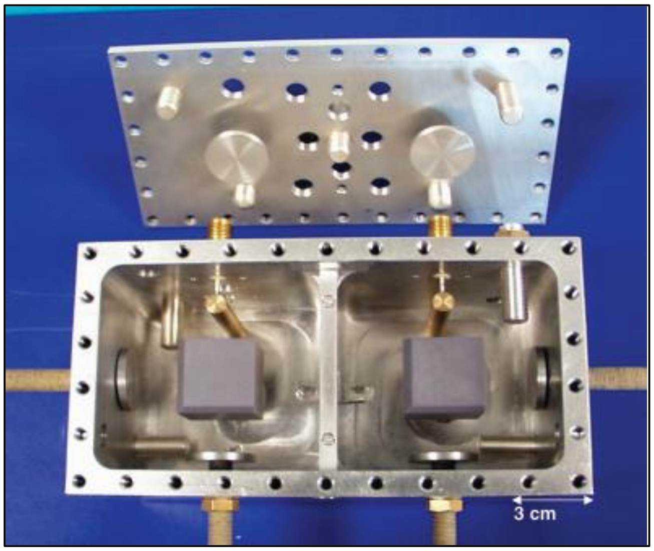

Fig 1: Silver-coated cavity with pucks used in filter and resonator technology[1].

On the other hand describing the engineering aspect in brief; the base station subsystem is composed of two parts that communicate across the standardized abs interface allowing operation between components made by different suppliers

1. Base Transceiver Station (BTS)
2. Base Station Controller (BSC)

In mobile communications, a BTS holds the radio transceivers that define a cell and coordinates the radio-link protocols with the mobile device. The BTS is the networking component of a mobile communications system from which all signals are sent and received. A BTS is controlled by a base station controller. A BTS is commonly referred to as a "cell phone tower." The BTS encodes, encrypts, multiplexes, modulates and feeds the RF signals to the antenna. It communicates with mobile station and Base Station Controller (BSC). It consists of Transceivers (TRX) units.The BSC manages radio resources for BTS, assigns frequency and time slots for all MS's in its area. It communicates with Mobile Switching Center (MSC) and BTS. MSC is the heart of the network which manages communication between Global System for Mobile Communications (GSM) and other networks. MSC does gateway function while its customer roams to other network.
Thus one of the solutions to the network hassle is related to the chemical aspect *i.e. quality of the resonator* used in the base station of the mobile phone. It is, therefore, necessary that TCs should try to improve the situation by the installation of temperature stable resonator with low dielectric loss i.e. high quality factor ($Q \times f > 200{,}000$ GHZ at its base stations.
The production of dielectric ceramics and resonators has emerged as one of the fastest growing areas today in electronic ceramic manufacturing due to the worldwide revolution in microwave-based communication technologies [1-3]. In this regard, complex perovskite ceramics have been extensively studied for their applications to dielectric resonators at microwave frequencies. It is well established that complex perovskite ceramics, with the general formula Ba $(B'_{1/3}B''_{2/3})$ O_3 (B′=Mg, Zn; B″ =Ta, Nb), exhibit very good dielectric properties at MHz range as well as GHz [4, 5]. Ba $(Zn_{1/3}Ta_{2/3})$ O_3 (BZT) is one of the most important in this group because of its relatively high dielectric constant ($\varepsilon_r > 25$), high quality factor (Q x $f \approx 80{,}000$–$150{,}000$ GHz) or ultra-low loss tangent (tan $\delta < 2 \times 10^{-5}$ at 2 GHz) and ability to achieve near-zero temperature coefficient of resonant frequency ($\tau_f \approx 0$) [6, 7].
Preparation of dielectric materials with optimal properties for wireless applications requires special thermal treatments due to the difficult control of the cationic ordering [8-10]. The processing of BZT is, however, complex and materials loss as well as the development of Zn/Ta site ordering can occur during sintering and annealing affecting both the X-ray intensities and the microwave dielectric properties [11-17]. The formation of complex oxide materials into dense ceramic resonators with optimized dielectric properties requires careful and demanding processing. BZT has excellent materials properties when processed correctly but is difficult to optimize on a commercial scale. This is a significant problem due to the cost and scarcity of Ta. The atomic-scale structure of BZT depends sensitively on the processing conditions since they control the extent to which the octahedral B sites of the parent simple perovskite are occupied in an ordered manner by the Zn and Ta cations. [18-25].

Experiment, Discussion and Results

BZT samples were prepared by solid-state reaction. The starting materials were $BaCO_3$ (99^+ %, Sigma Aldrich, USA), ZnO (99^+ %, Sigma Aldrich, USA), and Ta_2O_5 (99%, Sigma Aldrich, USA). The starting materials were dried at 500ºC for 10-12 hrs in Muffle furnace. Different batches of samples were prepared by weighing the stoichiometric quantities of the constituents. The processing conditions applied for different batches of samples were varied. Structural analyses and investigations on the evolution of phase composition in isothermal conditions were performed by powder X-ray diffraction (XRD); 2θ scans between 10 and 75º were determined using Bragg-brentano diffractometer (Bruker D8, Germany) with Cu - Kα radiation and dielectric measurements were done using C50, Alpha-A Novocontrol Broadband, a high performance frequency analyser.

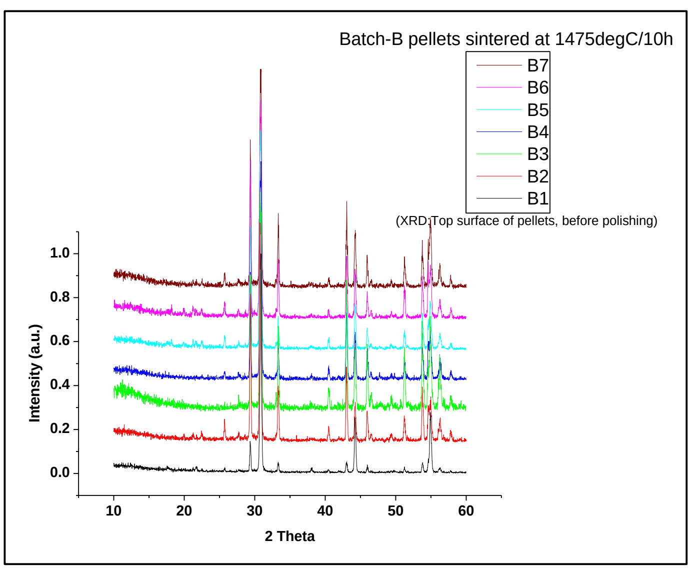

Fig 2: X-ray Patterns of one of the batches (Batch-B) samples.

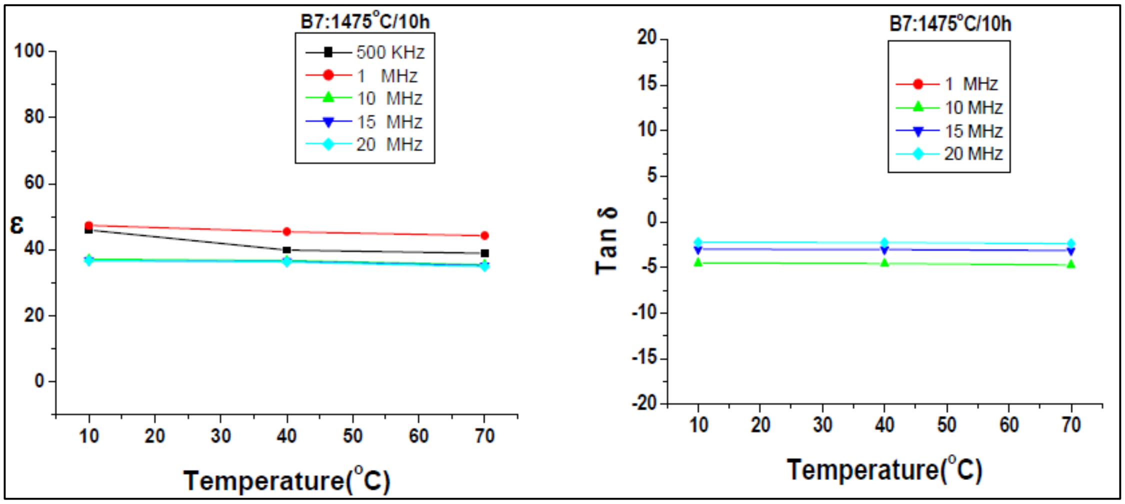

Fig 3: Plots of Dielectric constant (ε) and Dielectric loss (Tanδ) of one of the batches of samples (Batch-B).

The processing conditions were found to affect significantly the dielectric properties of the materials. Most of the samples exhibited very good range of dielectric constant (ε) from 35 to 50 and the dielectric loss (Tanδ) ≤ 0 up-to 20 MHz. These materials showed excellent dielectric properties. Although tantalate high *Q* perovskites such as BZT and BMT have been commercialized, in the last few years, economic factors associated with the high cost of Ta_2O_5 have increased the focus on their niobate counterparts like Ba $(Mg_{1/3}Nb_{2/3})$ O_3 (BMN) and $BaZn_{1/3}Nb_{2/3}O_3$ **(**BZN) as prospective candidates to substitute expensive tantalate perovskite like BZT and BMT.
Microwave (MW) ceramic resonator market for base station technology has now matured and industry is focused primarily on cost saving and improving *Q*. New dielectric ceramics are required as components of base-station filters for next-generation microwave communication networks and researchers have been working in this field and quite a good number of materials have synthesized.

Recommendations

Tele-communication companies should strive to get quality materials, trouble-free installations and total communication services that will allow them to maintain quality service and business. The overall review of both the chemical and technical aspects of the materials used as resonator could be the only solution to the problems like signal attenuations, SMS jam, and cross-talk etc. in the Tele-communication/Mobile phone network so as to provide quality service to the customers.

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