Pramāṇa – J. Phys., Vol. 35, No. 4, October 1990, pp. 361–368. © Printed in India.

Microwave losses in ABO_3 type perovskites

S C DEORANI, U C NAITHANI* and B S SEMWAL*

Department of Physics, Government College, Sawaimadhopur 322001, India
*Present address: Department of Physics, Garhwal University, Srinagar 246174, India

MS received 22 February 1990; revised 14 May 1990

Abstract. Using Green's function method, microwave lossess were theoretically calculated for $BaTiO_3$, $SrTiO_3$ and $KTaO_3$ ferroelectric perovskites. In microwave range, an increase in frequency is followed by an increase in the dielectric loss. In the paraelectric phase, the dielectric loss decreases with increasing temperature showing the Curie-Weiss behaviour of the tangent loss.

Keywords. Ferroelectrics; perovskites; soft-mode; anharmonicity; microwave-loss.

PACS No. 77·40

1. Introduction

The investigation of dielectric properties provides an important approach to the understanding of intra- and -inter molecular interactions, modes of motion and confirmational changes in the macromolecules. The temperature and frequency-dependence of the dielectric loss is the subject of considerable interest due to their extensive use in optical communication, memory display, temperature control devices, ceramic industry, etc. It is well known that several interesting temperature-dependent properties of ferroelectrics result from the temperature-dependence of the low lying transverse optic mode of vibration (Cochran 1969). Microwave losses in displacive ferroelectrics (BT, ST etc.) have been reported experimentally (Rupprecht and Bell 1961, 1962; Rupprecht *et al* 1961). Above the phase transition temperature, the results of the loss measurements can be represented by the temperature and frequency-dependence of the microwave loss tangent ($\tan\delta$) as

$$(T - T_c)\tan\delta = \omega(\alpha + \beta T + \gamma T^2), \quad (1)$$

where the parameter α depends strongly on the defect concentration. Parameters β and γ are third and fourth order anharmonic interaction terms which are temperature-independent but vary linearly with the frequency. Rupprecht and Bell (1961) found that in cubic $SrTiO_3$, the field independent loss tangent goes through a minimum at about 170 K with a much steeper slope on the low temperature side of the minimum than on the high-temperature side. The temperature-dependence of the loss tangent for the damping process is expressed as

$$\tan\delta = \gamma/(\Omega^2 - \omega^2) \approx \gamma/\Omega^2 \sim 1/(T - T_c).$$

Impurity scattering provides the sharp rise of the loss tangent on the low-temperature side of the curve. The microwave frequency was taken from 21–22 GHz.