Abstract
The optical property of Beta Barium Borate (β-BBO) in the terahertz region (0.2 THz to 12 THz) was studied using a broadband air photonic terahertz time-domain spectrometer. The crystal orientation and frequency dependence of β-BBO refractive index and absorption coefficient were experimentally investigated over the temperature range of 10 K to 293 K. Four TO phonon modes were observed below 3.5 THz. The behavior of these phonon modes at different temperatures has been characterized.

Introduction
Although many major technical advances have been witnessed in developing a strong THz source, there is still a strong need to develop intense and broadband THz wave sources. With its large birefringence, remarkable nonlinear coefficients and high damage threshold, β-BBO make itself potential strong THz source via optical rectification with the excitation of intense ultrashort laser pulses. Despite some previous work on BBO, a more comprehensive understanding of the BBO’s properties in the THz range will result in better utilization of the BBO as efficient THz emitters.

Optical property of BBO crystal

As temperature is decreased from 293 K to 10 K, the reduced homogeneous broadening also resulted in considerably narrower absorption lines. In addition, the resonances centered at 2.14 THz and 2.50 THz progressively shifted towards higher frequencies at lower temperature, while the resonance centered at 1.75 THz shifted toward lower frequency. 2.14, 2.50, and 2.83 THz phonon modes can be described as translations of $\text{Ba}_2$ while the 1.75 THz phonon mode is described as the libration of $(\text{B}_3\text{O}_6)^3^-$ rings.

Conclusion
The birefringence, absorption coefficient, and refractive index of BBO crystals in THz frequency range have been systematically studied. The results show that the BBO crystal has low absorption, large birefringence, and strong dispersion below 3.5 THz. BBO crystals could be of great importance for a variety of potential applications in the terahertz range such as THz generation, amplification and detection and THz wave manipulation.

Acknowledgement
This work was partially supported partially by Gordon-CenSSIS, the Bernard M. Gordon Center for Subsurface Sensing and Imaging Systems, under the Engineering Research Centers Program of the National Science Foundation (Award Number: EEC-9986821) and by the Office of Naval Research. This project fits level 1: Fundamental Science.

Reference