

Article

# THz Pyro-Optical Detector Based on LiNbO<sub>3</sub> Whispering Gallery Mode Microdisc Resonator

Alessandro Cosci <sup>1,2,\*</sup>, Matteo Cerminara <sup>3</sup>, Gualtiero Nunzi Conti <sup>2</sup>, Silvia Soria <sup>2</sup>,  
Giancarlo C. Righini <sup>1,2</sup> and Stefano Pelli <sup>1,2</sup>

<sup>1</sup> Museo Storico della Fisica e Centro Studi e Ricerche “Enrico Fermi”, Piazza del Viminale 1, 00184 Rome, Italy; g.c.righini@ifac.cnr.it

<sup>2</sup> IFAC-CNR, Istituto di Fisica Applicata “Nello Carrara”, Consiglio Nazionale delle Ricerche, Via Madonna del Piano 10, 50019 Sesto Fiorentino, Italy; G.Nunziconti@ifac.cnr.it (G.N.C.); s.soria@ifac.cnr.it (S.S.); s.pelli@ifac.cnr.it (S.P.)

<sup>3</sup> Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa, Via della Faggiola 32, 56126 Pisa, Italy; matteo.cerminara@ingv.it

\* Correspondence: a.cosci@ifac.cnr.it; Tel.: +39-055-522-6394

Academic Editor: A. G. Unil Perera

Received: 7 December 2016; Accepted: 24 January 2017; Published: 28 January 2017

**Abstract:** This study analyzes the capabilities of a LiNbO<sub>3</sub> whispering gallery mode microdisc resonator as a potential bolometer detector in the THz range. The resonator is theoretically characterized in the stationary regime by its thermo-optic and thermal coefficients. Considering a Q-factor of 10<sup>7</sup>, a minimum detectable power of 20 μW was evaluated, three orders of magnitude above its noise equivalent power. This value opens up the feasibility of exploiting LiNbO<sub>3</sub> disc resonators as sensitive room-temperature detectors in the THz range.

**Keywords:** bolometer; THz; WGM; microdisc; LiNbO<sub>3</sub>

---

## 1. Introduction

Nowadays THz applications are emerging as a new frontier of technology. Several current studies are concentrating on both generating [1–5] and detecting [6–10] THz radiation. The detection systems mainly involve two different techniques, namely coherent and incoherent [11]. The former uses a heterodyne detection scheme where the signal coming from local oscillator (LO) is mixed with the signal being detected. An important parameter for the mixer devices is the electric field quadratic nonlinearity. Frequently used mixers are superconductor-insulator-superconductor (SIS) tunnel junctions [12], forward biased Schottky barrier diodes (SBDs) [13], superlattices (SLs) [14] and semiconductor and superconducting hot electron bolometers (HEBs) [15]. The main advantage in using heterodyne detection is that both the frequency and phase information are preserved. Where sensitivity is more important than spectral resolution, direct detection can also be used, including devices such as THz antennas [16,17] and thermal detectors, such as Golay cells [18,19], pyroelectric detectors [10] and bolometers [20]. The electro-optic effects induced in LiNbO<sub>3</sub> and other birefringent crystals are widely studied, and several detectors have already been developed [21,22]. One of the main disadvantages of LiNbO<sub>3</sub> is its high absorption coefficient in the THz regime, limiting the detection sensitivity. Furthermore, to obtain strong electro-optic effects, applications mainly involve the detection of high peak THz pulses. In this study we propose a new technique for THz sensing by means of a LiNbO<sub>3</sub> microdisc resonator. Besides its good sensitivity to high peak THz pulses, its small dimensions are extremely sensitive to temperature shifts due to CW (continuous wave) THz absorption as well. Whispering gallery mode (WGM) microresonators are optical resonators characterized by a high quality factor, up to 10<sup>11</sup> [23], and, therefore, they are suitable for high-precision sensing applications [24]. LiNbO<sub>3</sub> microdiscs were already widely used for thermal and electro-optic applications [25,26]. Like MgF<sub>2</sub> [27,28], its birefringent behavior