



**HAL**  
open science

## GHz Micro-modulator for telecommunication based on SBN and KTN bulk crystals

M. Bouvrot, J.C. Ponçot, Cindy Guichard, L. Larger

► **To cite this version:**

M. Bouvrot, J.C. Ponçot, Cindy Guichard, L. Larger. GHz Micro-modulator for telecommunication based on SBN and KTN bulk crystals. CLEO/ Europe-IQEC 2009, Jun 2009, Munich, Germany. pp.1-1, 10.1109/CLEOE-EQEC.2009.5196511 . hal-00472357

**HAL Id: hal-00472357**

**<https://hal.science/hal-00472357>**

Submitted on 19 Apr 2021

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

# GHz Micro-Modulators for telecommunications based on SrBaNb<sub>2</sub>O<sub>6</sub> and KTaNbO<sub>3</sub> bulk crystals

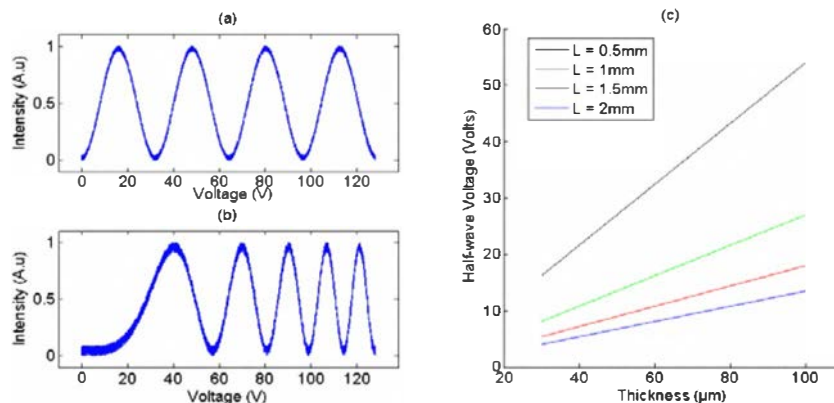
M. Bouvrot<sup>1,2</sup>, J.C. Poncot<sup>1</sup>, C. Guichard<sup>1</sup>, L. Larger<sup>2</sup>.

1. Institut Pierre Vernier – Dpt. Technologique, Franche-Comté Innovation & Transferts, 39 Av de l'Observatoire B.P. 1445, 25007 Besançon Cedex, France.

2. Université de Franche-Comté, Institut FEMTO-ST, 16 Route de Gray, 25030 Besançon Cedex, France.

A crucial aspect in current telecommunications research is the search for network components and technologies of reduced size and fabricated from functional materials suitable for operation around 1550 nm. Most current modulation technologies are based on Lithium Niobate crystals using optical indiffused waveguides, which allows optimal light coupling with crystal lengths close to 10 cm. In LiNbO<sub>3</sub>, the  $r_{33}$  coefficient is around 30 pm/V, resulting in waveguide lengths of ~10cm in order to obtain sufficient electro-optic effect for high modulation rate. The electrodes need however to be carefully designed (travelling wave electrodes), in order to allow also for a broad modulation bandwidth. However, for highly doped SBN,  $r_{33}$  is significantly higher from 400 to 1400 pm/V which yields comparable electro-optic effect using sub-cm interaction lengths. A smaller device also reduces the difficulty of broadband electrode design. Also another alternative material was investigated in this context with similar dimensions, KTN crystal, which is exhibiting a nonlinear Kerr effect instead of the linear Pockels one. In this paper, we report the development of micro-modulator technology using bulk SBN and KTN crystals, materials which exhibit giant electro-optical coefficients  $r_{33}$ .

Although the possibility to use these materials for modulation has been known for some time [1,2], they have not been applied in practice because of the lack of technologies to reduce crystal size to dimensions compatible with integrated optics. The originality of our approach relies on a non-guided light beam, and a vertically applied field through a 200 $\mu$ m-thickness crystal. We demonstrate the first sub-mm<sup>3</sup> electro-optical modulation chip. Such a size was achieved through a novel crystal thinning technology. Two bulk crystals have been investigated, SrBaNb<sub>2</sub>O<sub>6</sub> and KTaNbO<sub>3</sub>. Their size was 10x10x1mm, and after thinning steps and electrode deposition via photolithography, we obtained around thirty operating modulators from the same initial crystal. Chips are cut and polished, before being tested. Light at 1550 nm is injected and collected through matched GRIN lenses, and a vertical electro-optic field is applied via a voltage on the electrodes.



**Figure 1:** Light modulation obtained in 4mm long and 200 $\mu$ m thick bulk crystals. (a) Results obtained in SBN crystal. (b) Results obtained in KTN crystal. (c) Evolution of half-wave voltage vs. thickness for different length of SBN crystal.

Our results with these micro modulators are shown in Fig. 1. A half-wave voltage around 40 volts was obtained for a 4mm long and 200 $\mu$ m thick SBN crystal (Fig. 1a). Since this crystal is based on the linear Pockels effect, we can reduce by a factor of 3 (~15V) the half-wave voltage as the thickness was decreased down to 70 $\mu$ m. Fig. 1b is the modulation transfer function obtained with a KTN crystal, exhibiting a quadratic Kerr effect. Fig. 1c shows the achievable half-wave voltage for this bulk configuration, versus crystal thickness. A modulation bandwidth of about 1GHz was already achieved for the 200 $\mu$ m thickness SBN crystal, without any specific design for bandwidth enhancement (size and shape of the electrodes). These results represent an important step towards developing reduced footprint modulation technology for developing new classes of optoelectronic components.

## References

- [1] J. M. Marx, O. Eknayan, H. F. Taylor and R. R. Neurgaonkar, "GHz-Bandwidth Optical Intensity Modulator in Self-Poled Waveguides in Strontium Barium Niobate" IEEE Photonics Tech. Letters, 8(8) (1024-1025) (1996).
- [2] J.E. Geusic, S.K. Kurtz, J.G. Skinner, S.H. Wemple, "Light modulation and Beam Deflection with Potassium Tantalate-Niobate Crystals" J. Appl. Phys., 37 (388-398) (1966).