Fast light self-trapping in isolated $LiNbO_3$ slab waveguide by pyroelectric effect

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Formation of spatial solitons or more generally self-trapped beams in slab nonlinear waveguides have been the subject of numerous papers. In the earliest studies, that involves the Kerr effect, a planar configuration is requested to obtain a stable propagation [1]. When saturating nonlinearities, such as the photorefractive effect, are used 2-D self-trapping in bulk media is possible. This arrangement has naturally triggered major studies [2]. Use of a saturating nonlinearity in planar configuration could also bring great benefits. Indeed, slab waveguides allow better beam control, improved performances and offer potential hybridization or integration with photonics and electronics components. In this context, lithium niobate crystal (LiNbO3) benefits from mature technological processes for both its growth and for fabrication of active and passive devices. In the present work, we demonstrate beam self-trapping at low CW power (submilliwatt) in an isolated thin $LiNbO_3$ film. The effect is triggered and controlled by a slight temperature increase of the slab waveguide. This original arrangement is characterized by self-focusing response time two orders of magnitude faster than in the bulk media. The specific underlying physics at the origin of this behaviour are discussed.

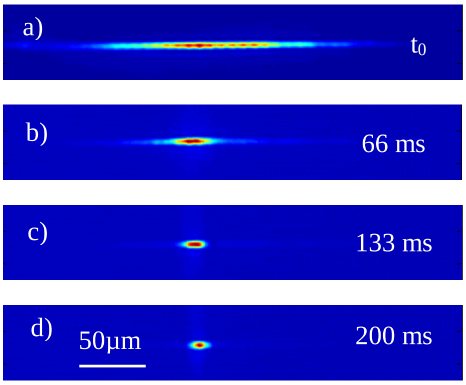

Fig. 1 Light distribution at the output face of the LiNbO3 slab waveguide when a 10µm (FWHM) beam is launched at the entrance face. Linear regime (a) and light distribution after successive expositions (b-d) of a 1mW pulse of 66ms duration when the waveguide temperature is increased to 40°C.

To fabricate the $LiNbO_3$ slab waveguide a 500µm thick photonic grade z-cut congruent LiNbO3 wafer is first bonded to a silicon substrate using a UV curing adhesive. The $LiNbO_3$ crystal is then mechanically ground and polished to form an 8µm thick slab waveguide isolated from the silicon substrate by a few micrometers thick adhesive. This hybrid wafer is then diced to form 10mm long samples. A 10µm (FWHM) diameter beam spot at 532nm wavelength is then launched at the input face of the waveguide. A typical observation is presented in figure 1. Before sample temperature is raised light freely diffracts along propagation (fig. 1a). When temperature is increased to 40°C fast and efficient beam self-focusing is observed (fig1 b-d). A short response time is one of the remarkable features. For instance, best focusing is reached in less than 200ms for a 1 mW input power beam for the experiment described in figure 1. When compared to a bulk configuration [3], a two orders of magnitude improvement is obtained. We attribute it to the very specific photorefractive charge redistribution dictated by both the isolated $LiNbO_3$ film and the pyroelectric effect. Observed dynamics along with discussion on the underlying physics will be detailed in the presentation. Memorized channel waveguides left by the self-trapped beams will also be considered.

References

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35 words abstract :

Beam self-trapping by pyroelectric effect is reported in a $LiNbO_3$ film. The underlying physics specific to this arrangement is especially characterized by a response time orders of magnitude faster than in bulk $LiNbO_3$.