QUASI-PHASE MATCHED OPTICAL PARAMETRIC GENERATION AT 1.54μm

FINAL REPORT

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ABSTRACT

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13. ABSTRACT (*Maximum 200 words*)
Efficient generation of 1.54 μm optical radiation can play a big role in eye safe detection and communication. Quasi-phase matching has the potential to provide efficient conversion to 1.54μm. Our approach to develop a quasi-phase matched device at 1.54 μm is to use photorefractive self-induced waveguides along with alternating ferroelectric domains to phase match. In this approach the waveguide maintains a high intensity throughout the crystal while quasi-phase matching maintains phase matching conditions. The most important results from our study is that we have demonstrated that we can create 10 micron waveguides in every direction throughout the crystal forming 10 micron optical waveguide circuitry throughout the bulk. Current work is focused on developing this fixed waveguide for quasi-phase matched second harmonic generation.

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Enclosure 1

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FIGURES AND ILLUSTRATIONS

Fig. 1. Shows a top view of a photorefractive crystal with a 10 micron laser beam passing through it. The top of the pictures shows the beam expanding due to diffraction. The bottom of the picture shows what happens when a voltage is applied to the crystal. The beam is seen to trap at 10 microns and form a spatial soliton.

Fig. 2. Shows the experimental apparatus used to fix or make permanent the self-induced waveguides. The argon-ion laser is used to produce both a soliton beam and a background beam used to excite charge to the head-to-head domain regions and lock the domain pattern.

Fig. 3. Shows the beam profile at the entrance face; at the exit face without an applied voltage; at the exit face with an applied voltage; and at the exit face after fixing the waveguide.

Fig. 4. On the left is shown that an input higher order mode is not guided by the fixed waveguide. This demonstrates that the fixed waveguide is single mode waveguide. On the right is the beam profile of a HeNe beam injected into the waveguide. As is easily seen, the waveguide does an excellent job in guiding beams that do not induce a waveguide of their own.

Fig. 5. On the left is show two input beam in the horizontal plane of the crystal. The two beam are seen to give a combined diffracted output. However, when a voltage is applied the two beam are seen to merge at the output forming one soliton beam. When this waveguide is fixed, a Y-junction is formed in the crystal. The output profile remains the same independent of one or two inputs.

Fig. 6. Shows that the Y-junction can be operated in reverse. One input HeNe beam is shown splitting into two beams. The two output HeNe beams mirror the two input waveguide forming argon-ion laser beams

Fig. 7. The same situation as in figure 5 except that the two input beams are now in the vertical plane. Together, figures 5 and 7 show that we are able to simultaneously fix or make permanent any array of waveguides in the crystal, thus making possible optical circuitry in the bulk.

SUMMARY OF THE MOST IMPORTANT RESULTS

The photorefractive waveguide is created by a steady state screening photorefractive soliton. Steady state screening photorefractive solitons occur when an external voltage is applied to a photorefractive crystal and the electric field is partially screened within the incident light beam due to the higher conductivity created by the light-induced excited charge carriers. As a result of the different electric field values within and around the optical beam the refractive index is correspondingly modified via the Pockels effect. The resulting modified index distribution then traps the optical beam.

While there are many applications that depend on the fact that 2-D photorefractive waveguides are self-induced and easily erased, for parametric generation it would be advantageous to have a permanently induced 2-D waveguide in the crystal. For example, one can envision a 2-D waveguide that can maintain a 10-micron beam diameter over long propagating distances (Fig. 1.) and, therefore, high conversion efficiency for low intensity optical beams. By playing with paraelectric to ferroelectric phase transition we have found it possible to make permanent waveguides in our photorefractive crystals. At the same time we are also trying to create alternate ferroelectric planes to quasi-phase match.

Prior to the present work, all photorefractive solitons explored were supported by trapped charge carriers. In other words, the waveguide structure induced by the solitons always disappeared if the applied field was turned off while the crystal is still illuminated. This is because the trapped electrons are re-excited and eventually and experience transport due to diffusion alone, which gives rise to a charge distribution that cannot support solitons. For many applications, however, it is essential to actually "impress" the waveguide structure into the crystalline lattice, by moving ions. In principle, two methods can be employed for transforming the electronic waveguide structure into an ionic deformation: ion drift and ferroelectric space-modulated poling. We have recently successfully employed the latter method and were able to permanently fix the waveguide structure (as induced by a soliton) into an ionic structure, which survives in room temperature when the applied field is removed, even upon intense illumination. On the other hand, these permanent waveguide can be easily erased (when desired) by applying fields that are larger than the coercive field in the dark (or upon uniform illumination).

The apparatus (Fig. 2.) consisted of an argon laser, focusing optics, and an optical imaging system. The focused 12μ beam diameter on the input face of the 1cm SBN:75 crystal normally expanded due to diffraction to about 100μ on the exit face. When a voltage was applied, the beam self-trapped and formed a photorefractive spatial soliton as the beam diameter at the output face was reduced to 12μ. When the applied electric field was switched off, the remaining screening space charge field in the region of the 12μ beam flipped the domains, so that in this region, the crystal was oppositely poled and the charge at the head-to-head domain walls caused an electric field to be created in the original applied field direction. As a result, a waveguide was fixed in the crystal and guided the laser light with zero applied voltage and no background beam of any type. The beam diameter on the crystal entrance face is shown on the left of Fig. 3, the diffracted output beam in the center, while the diameter at the exit face after fixing is on the right. This waveguide showed no sign of diminishing after 24 hours of use, but could be erased using a large electric field and uniform illumination applied to the crystal. Fig. 4 shows the fixed wave guide guiding a HeNe laser beam while Figs. 5, 6 and 7 show a fixed y-junction. Together, these express the most important results from our study which is that we can create 10 micron waveguides in every direction throughout the crystal forming optical waveguide circuitry throughout the bulk.

Our future plan is to use the "fixed" waveguide to produce highly efficient parametric generation in SBN:75 using quasi-phase matching. This can be accomplished by reversing the domains and fixing in alternate 3μ planes along the propagation direction. In fact, we had hoped to complete this part before the project ended but doing a through job of fixing waveguides took more time than desired.

MANUSCRIPTS

1. Primarily isotropic nature of photorefractive screening solitons and the interactions between them, H. Meng, G. Salamo, and M. Segev, Optics Letters 23, 897, 1998.
2. Fixing the Photorefractive Soliton, M. Klotz, H. Meng, G. Salamo, M. Segev, and S. Montgomery, Optics Letters 24, 77 1999.

PARTICPANTS

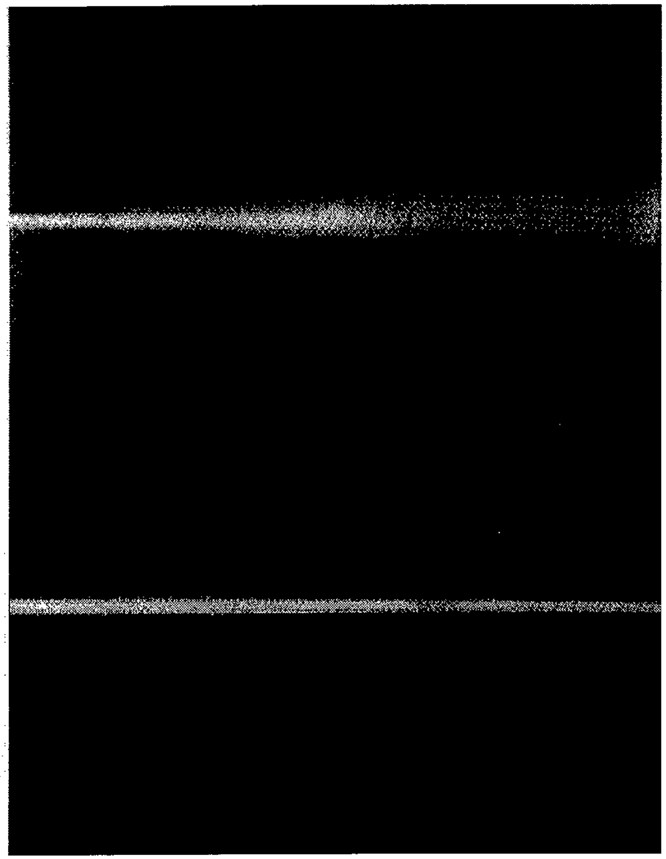
Mr. Meng received his Ph.D. degree at the University of Arkansas in the summer of 1999 as a result of support by this grant.

INVENTIONS

We have not reported or claim any inventions.

TECHNOLOGY TRANSFER

Although we hve not established a transfer of technology we will at the project completion.



Top view of a diffracted beam (above)and a trapped beam (below)

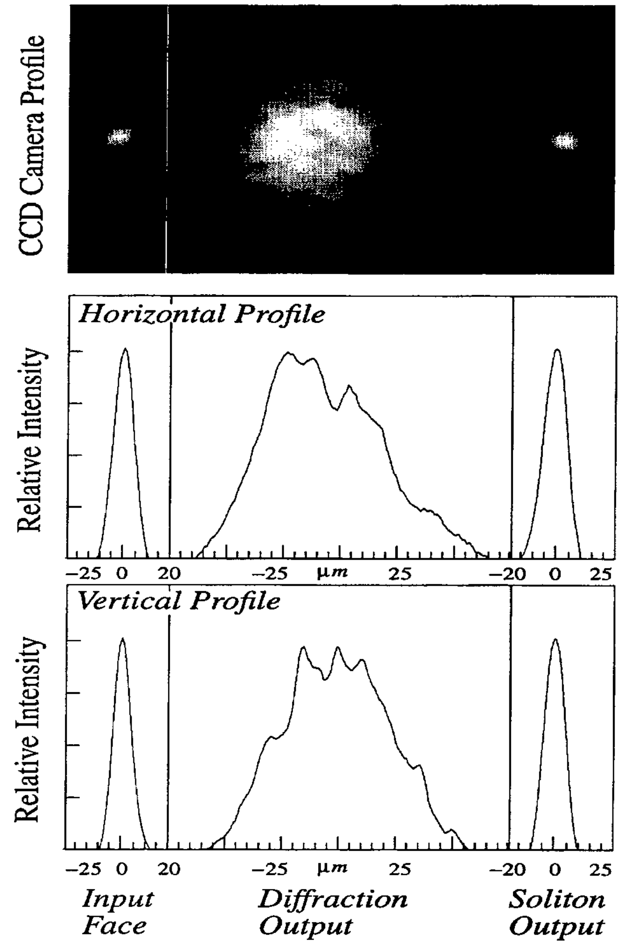


Fig. 1. Top view of crystal showing formation of a single fixed waveguide

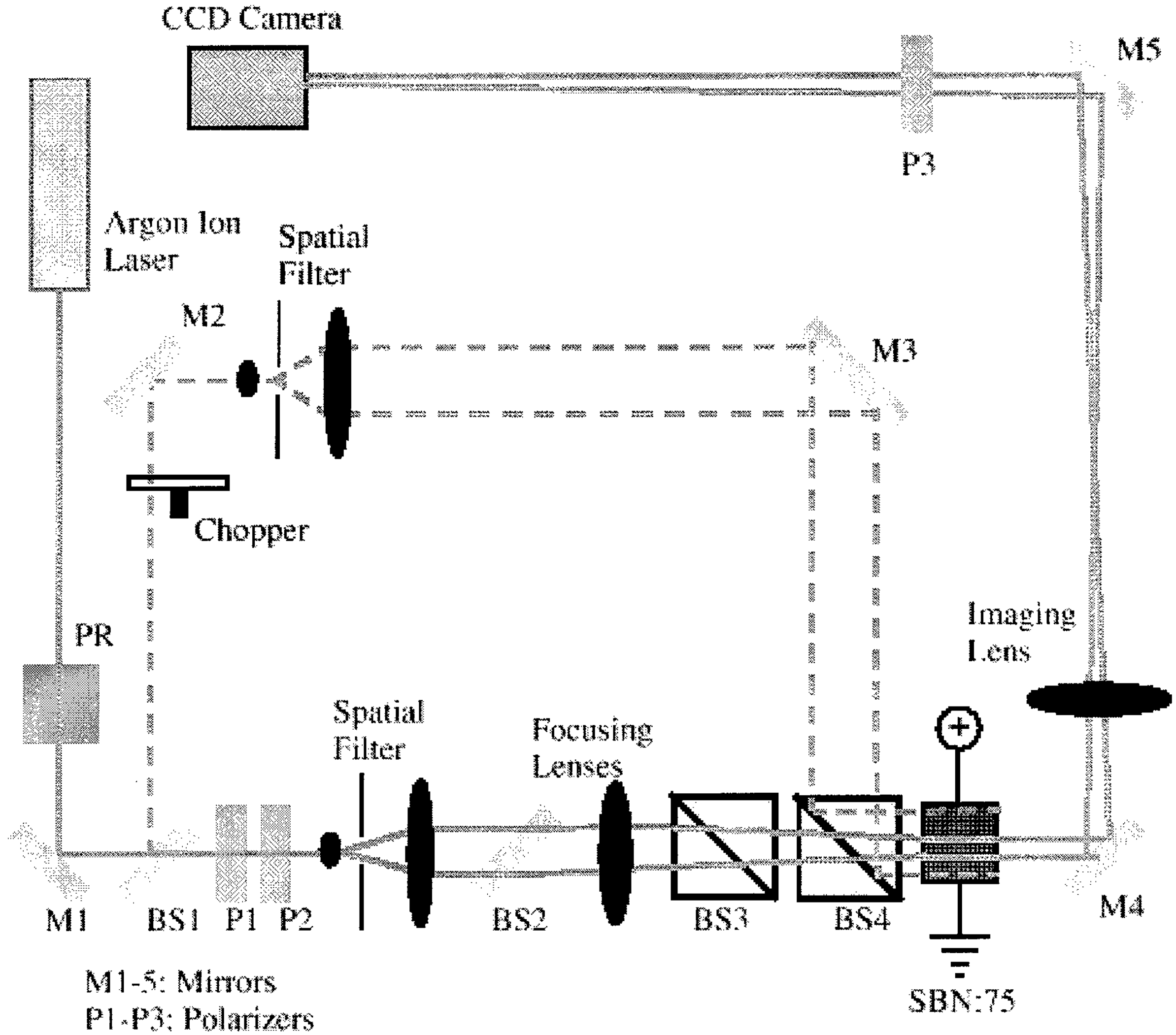


Fig. 2. Experimental apparatus for observing soliton formation and fixing

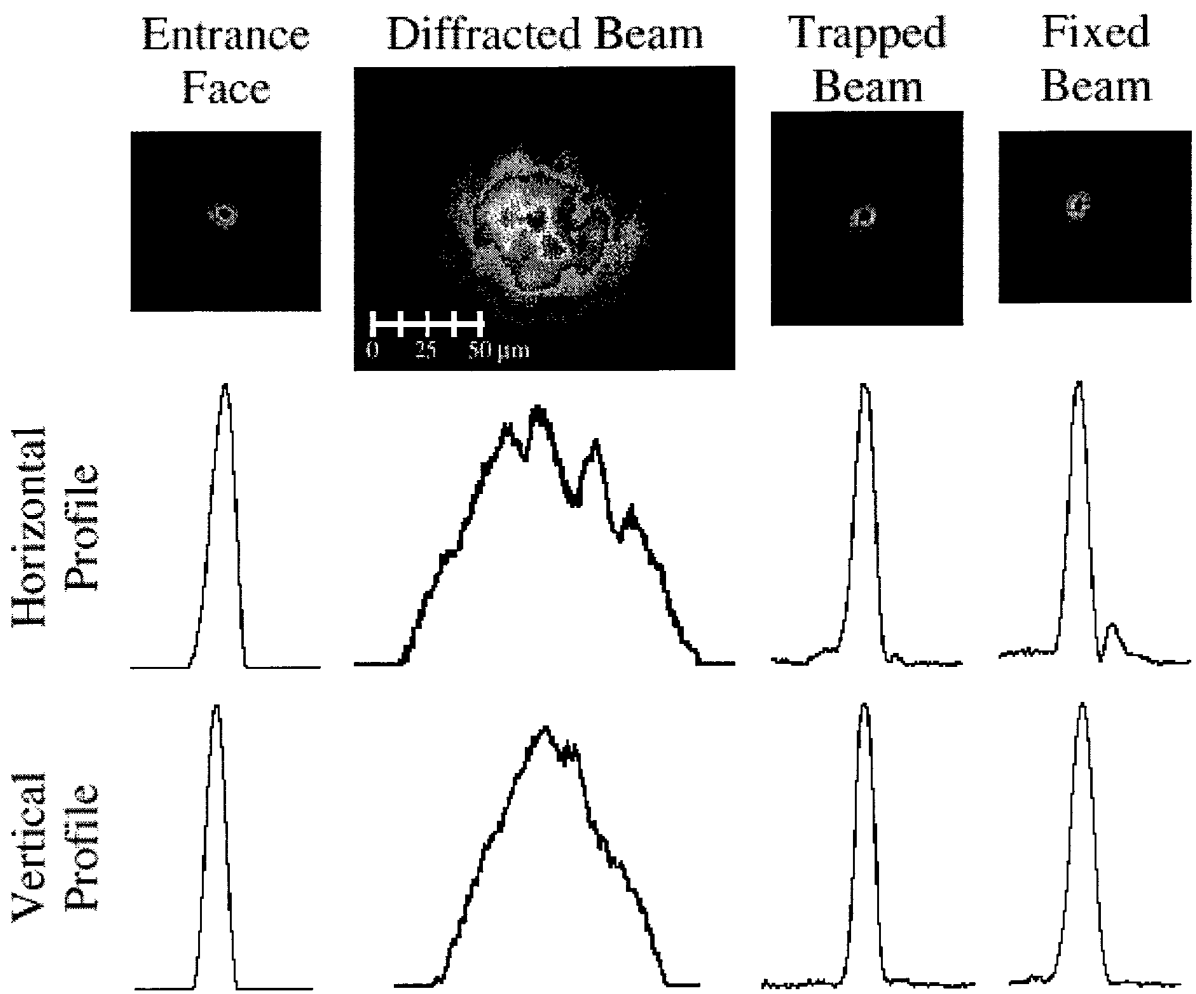


Fig. 3. Single Fixed waveguide is shown on the far right

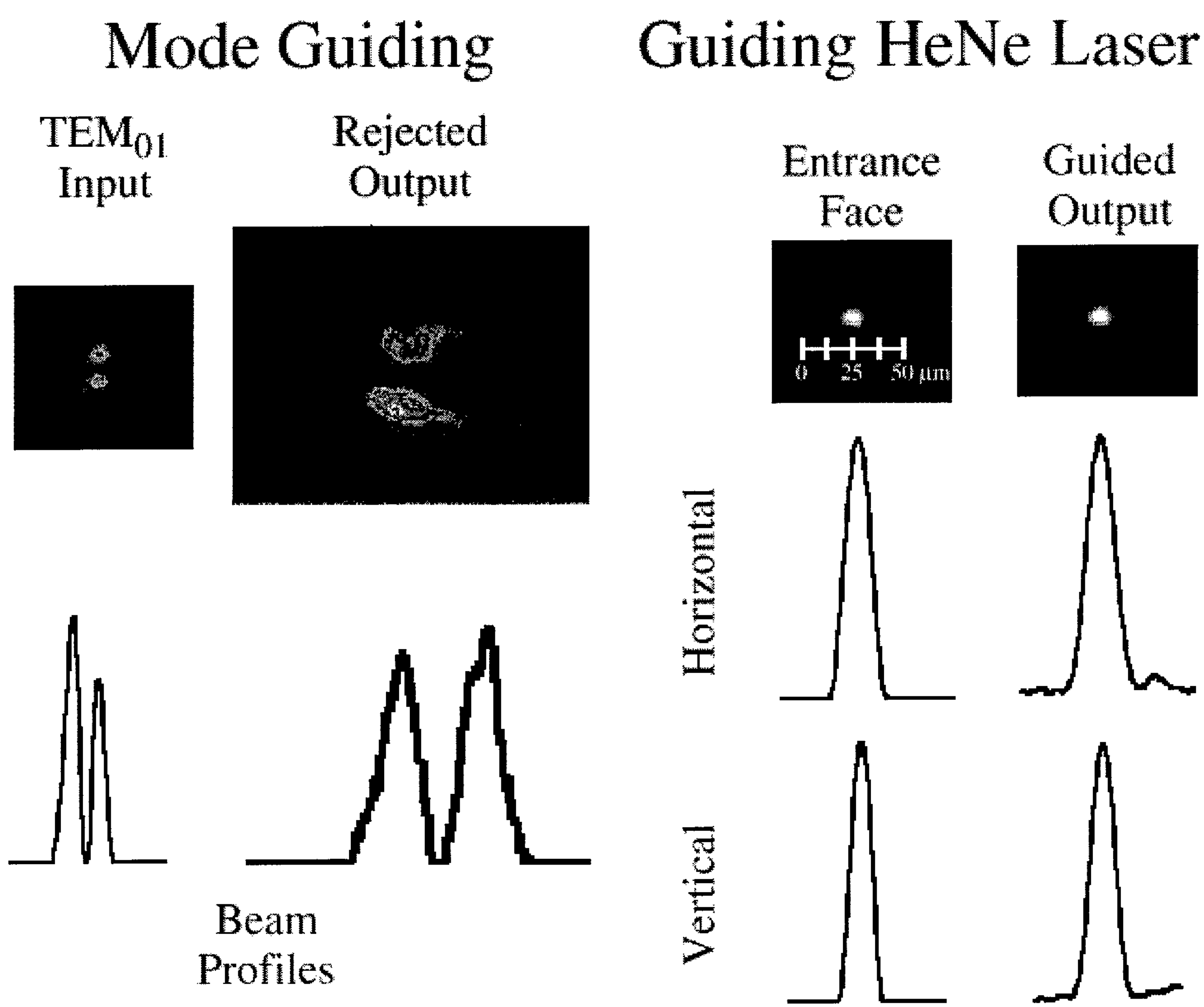


Fig. 4. Single fixed waveguide guiding a HeNe beam

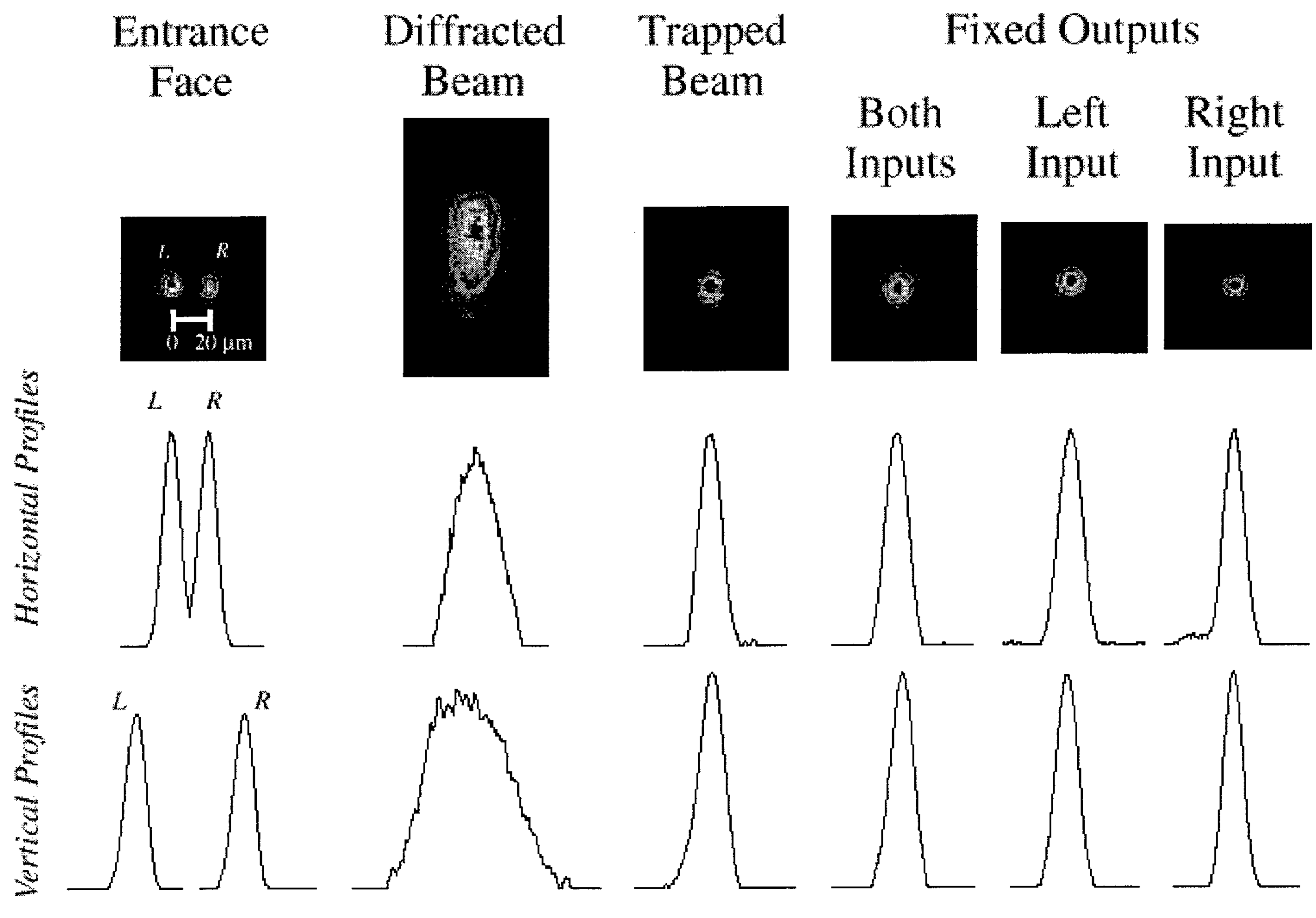


Fig. 5. Fixed Y-junction waveguide in the horizontal plane

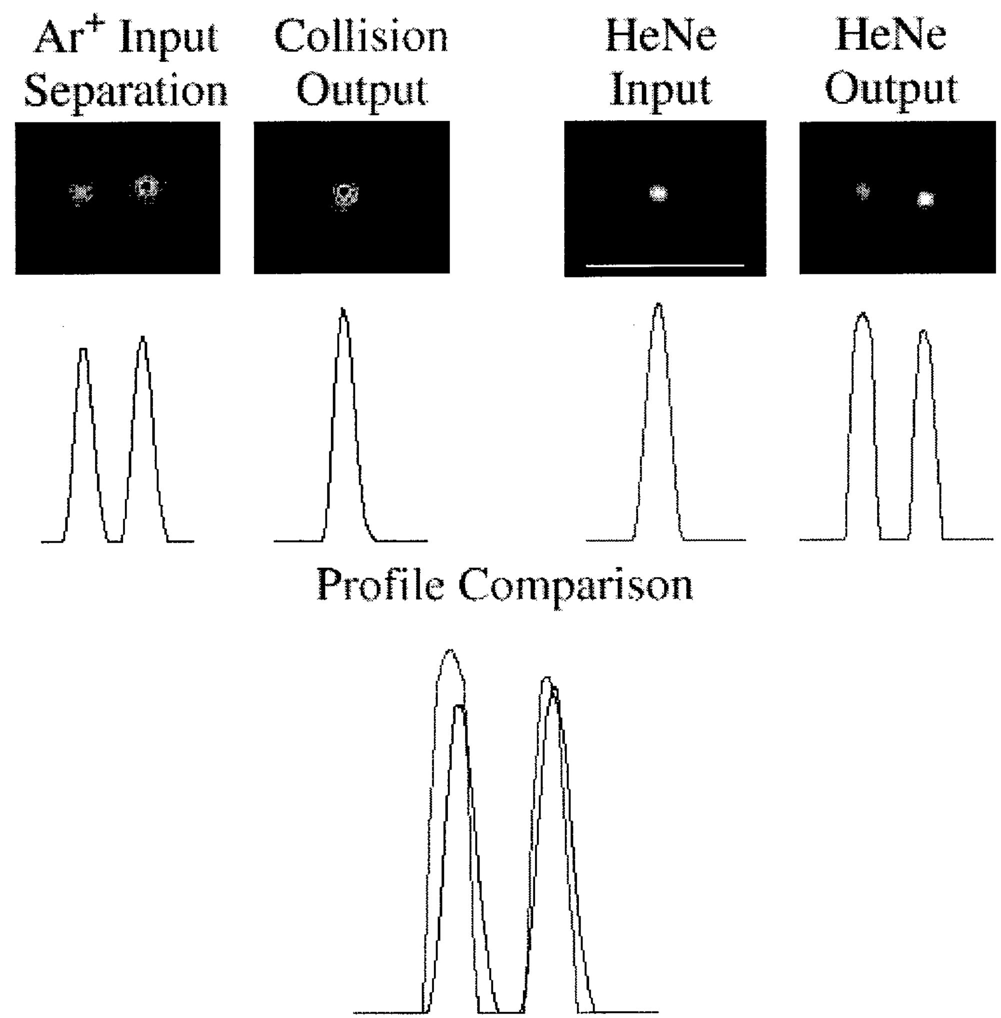


Fig. 6. HeNe injected into output of the Y-junction waveguide

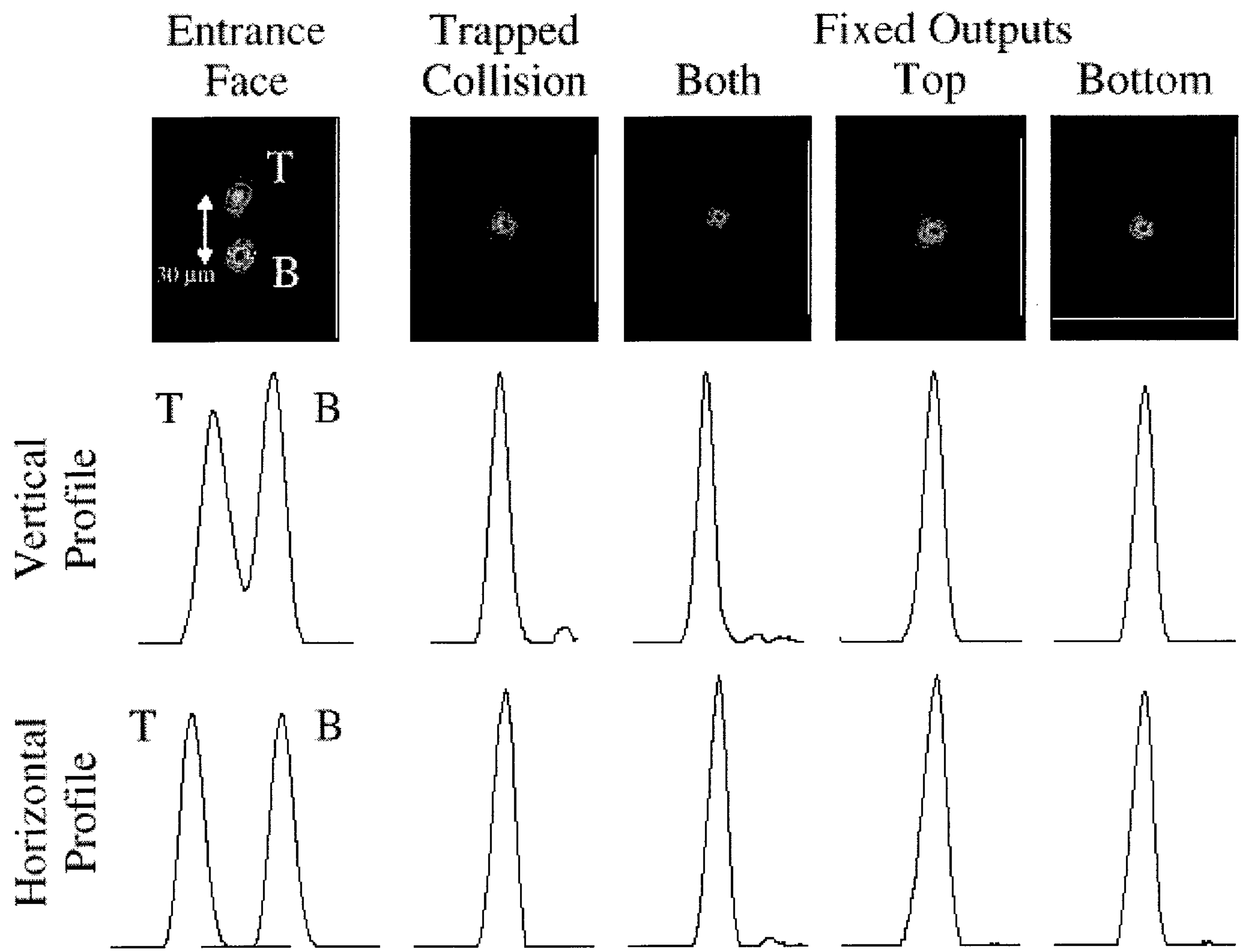


Fig. 7. Fixed Y-junction waveguide in the vertical plane