3.1 Post-implantation Annealing of $KNbO_3$ Waveguides

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The technique of ion implantation has proven to be well suited for the formation of permanent waveguides in $KNbO_3$ where structural phase transitions and chemical inertness have rendered the formation of $KNbO_3$ thin films, that possess the favourable nonlinear optical properties of the bulk crystal, very challenging or even impossible.

The fabrication of low-loss waveguides is essential for applications in integrated optics, e.g. compact frequency doublers and electro-optic modulators. In order to reduce the absorption losses that are induced due to ion beam irradiation, we have developed a low-temperature post-implantation annealing process that does not spoil these single domain $KNbO_3$ waveguides. Annealing at temperatures of 150 to 180^{o}C for about 10 hours was found to reduce the absorption losses by up to 9dB/cm at a wavelength of 457nm. Typical waveguide losses after annealing are ~6dB/cm at 457nm and ~2dB/cm at 633nm.

Investigation of the refractive index profile of the waveguide showed that the mode-confining index barrier produced by ion implantation is not affected by the annealing. This proves the excellent thermal stability of the waveguides. The annealing improved the frequency-doubling conversion efficiency in the waveguides by up to factor of three as expected from the reduction of the waveguide absorption loss.