3.1 Phase-Matched Second Harmonic Generation in $KNbO_3$ Waveguides

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$KNbO_3$ is one of the most promising materials for high efficiency frequency doubling of AlGaAs (~860 nm) and InGaAs (~980 nm) laser diodes and of diode-pumped solid-state lasers, e.g. the YAG:Nd (946 nm, 1064 nm) laser, into the blue-green spectral range thanks to its large nonlinear optical coefficients and its favourable phase-matching (PM) conditions. Phase-matched second harmonic generation (SHG) is possible over a wide range of wavelengths either by temperature or angle tuning. In bulk crystals, temperature tuning is preferred because, in this case, the second harmonic and the fundamental beam do not walk off, and hence, a higher conversion efficiency can be achieved. However, for most applications the crystal is preferentially operated close to room temperature.

The use of channel waveguides eliminates the problem of walk-off for any of the possible PM configurations because both waves are inherently guided along the same direction. The technique of ion implantation has proven to be well suited for the formation of permanent waveguides in $KNbO_3$.

The detailed knowledge of the refractive index modification caused by the ion implantation process is a prerequisite to tailor waveguide frequency doublers. We have determined the index profiles of all three principal refractive indices of $KNbO_3$ as a function of the implantation parameters ion energy and ion dose. This knowledge allows us to design waveguides for frequency doubling of specific wavelengths of lasers.

In order to check the potential of forming waveguides on specially cut $KNbO_3$ crystals we have designed and successfully produced planar waveguides for frequency doubling a 1064 nm YAG:Nd laser. The experimental results are in good agreement with the theoretical modelling based on the index depth profiles.