



The non-stoichiometry of LN has been the main limitation for its high power applications, because of its Li-deficiency, leading to many intrinsic defects (vacancies, antisite defects etc.) and high disorder. The defect site can cause absorption and incorporation of impurities. The presence of impurities and defects degrade LN's damage resistant to optical radiation. In spite of defective nature, congruent crystals possess high optical homogeneity. The presence of these defects makes material less susceptible to various types of impurity incorporation added intentionally for desired application. The necessary charge compensation for the extrinsic defect caused by impurity atoms could be easily balanced by intrinsic defects. Therefore several types of dopant have been studied in the past (for various applications) like Mg, Zn, In and Sc to make material damage resistant to optical radiations, transition metal ions Fe, Mn, Rh, Ce and Cu for high density holographic data storage and rare earth ions Nd, Cr, Ho, Gd and Er for laser host materials.

In view of the above facts, various undoped and doped LN crystals have been grown from congruent melt composition (48.45 mol% Li_2O and 51.55 mol% Nb_2O_5) using Czochralski technique. The charge was synthesized from high purity 99.99% Li_2CO_3 , Nb_2O_5 powders. The mixture was ball-milled for several hours to ensure proper mixing. The well-mixed charge was fired first at 750 °C for 15h again grinded and fired at 1000 °C for 24h. This process was repeated to ensure the completion of solid-state reaction. The reacted charge was ground, remixed and palletized. These pallets were placed in a 50mm diameter and 50mm height platinum crucible for crystal growth runs in air atmosphere. The induction heating system of 30kW and 30kHz were used as a heater. The optimized pulling and rotation rates were in the range of 3 to 5mm/h and 25 to 15 rpm respectively. The pulling

and rotation rate were reduced gradually for better growth conditions. The growth chamber was prepared from zirconia refractory followed by zirconia felt inside quartz tube.

Platinum after heater position was adjusted in such a way to provide optimum thermal gradient for nearly flat growth interface and post growth cooling optimised for the crack free crystal. The post growth cooling was maintained at a rate of 25-30 °C/h initially up to 1000 °C, and thereafter 100 °C/h to room temperature. Typical sizes of the crystals grown were 20-25 mm in diameter and 30-40 mm in length. Fig L.16.1 shows crystal boules of undoped Cr and Mg doped lithium niobate crystals. Fig L.16.2 shows the wafers and fabricated elements from as grown undoped and doped (Mg, Cr and Cu) LN samples.

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L.17 Data acquisition software for frequency resolved optical gating

Ultrashort pulses (pulse width <10 ps) are in widespread use in physics, photochemistry and photobiology. One issue in working with ultrashort pulses is the need to characterize the pulse to get proper interpretation of experimental data. For example, in passing through a length of dispersive medium (e.g. glass) a transform-limited femtosecond pulse gets broadened in time and becomes chirped. A full characterisation of the pulse requires measurement of its time-dependent phase as well as amplitude. Frequency Resolved Optical Gating (FROG) is one of the most popular techniques used for measuring the time-dependent phase and amplitude of an ultrashort pulse. It involves the generation of a spectrogram or the FROG trace of the laser pulse under study in the form of a single two-dimensional picture with the time delay along one axis and the spectral frequency along the other axis. FROG can utilise any one of several nonlinear optical processes e.g. second harmonic generation, polarization gating etc. We have developed a complete data acquisition system for recording and displaying FROG traces for various experimental geometries

It can be used for both single-shot as well as multishot configurations. As the programme is based on the earlier developed PROMISE software, it has the entire image processing capabilities of PROMISE. The programme controls two optical delay stages and acquires the data from the CCD detector at the spectrograph output. The FROG measurement is done in the following manner. First the input beams are set at zero delay to set the spectrograph and the



Fig. L.16.1 As grown undoped, Mg and Cr doped LN crystal boules

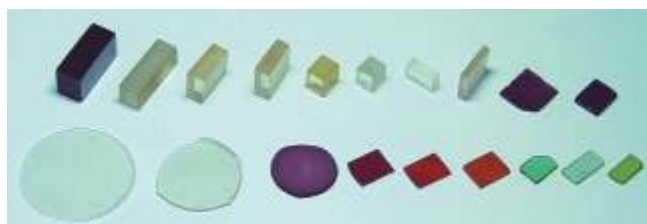


Fig. L.16.2 Fabricated elements of undoped and doped (Mg, Cr and Cu) LN crystals



FROG spectrum acquisition parameters. The spectrograph is set to obtain a good image of the FROG spectrum on the CCD in the live display mode. The height of the spectrum can be several lines of the CCD depending on the spot size at the entrance slit. One of the lines is selected (or several lines can be binned to improve S/N ratio) to be stored by marking with two cursors. This selection remains valid for the whole duration of the experiment. The programme moves the delay stage and at each step acquires the CCD image. However, instead of saving the whole frame only the selected line (or binned lines) is saved from each frame. This one trick reduces the computer memory requirement enormously and enables a large number of spectra to be saved in each run. As the delay stage moves, two images are displayed on the screen. Fig. L.17.1 shows the screen display midway of a FROG trace recording of a 300 fs pulse using the second harmonic generation based FROG showing two images. The image on the left shows the autocorrelation spectrum at the current delay stage position. The image on the right is the cumulative picture of all the spectra stored till the current position i.e. the FROG trace in evolution. Thus, the FROG trace can be monitored on screen as the experiment progresses. The delay varies along the vertical axis and the wavelength along the horizontal axis. Using the image processing tools of PROMISE, the image can be quickly tested for any asymmetry in the trace, proper wavelength spread of the second harmonic spectrum etc before the data is used for phase retrieval. The programme runs under Windows 95/98. The acquisition time for the FROG trace depends on the type of PC, the frame grabber card and the number of frames captured for the full trace.



Fig. L.17.1 SHG spectrum at current position(left), the FROG trace(right) till the current position

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L.18 Up gradation and Second harmonic conversion of 0.1TW, 25ps Nd : phosphate glass laser chain for dual operation at 0.527mm and 1.054mm wavelength

High power pulsed Nd:glass lasers delivering peak power of hundreds of gigawatt in multi-picosecond duration

pulses are widely used for a variety of scientific investigations such as intense X-ray generation, laser-plasma interaction, nonlinear harmonic generation etc. Second harmonic conversion of the output at 1.054mm is of great interest in view of several advantageous features of laser-plasma interaction using shorter wavelength laser radiation, e.g. better absorption, higher X-ray conversion, less amount of hot electrons generation etc. In addition, conversion to second harmonic greatly increases the peak to foot intensity contrast ratio of the laser pulse, which is required to prevent formation of a low temperature, long scale length plasma on the target prior to the arrival of the main laser pulse. We had earlier set up a 100GW, 25ps Nd:phosphate glass laser chain for laser plasma interaction studies. This has been recently upgraded by adding one more amplifier stage enhancing its output power to 160GW and frequency up-converted it to second harmonic using a KDP crystal. This laser chain can now be operated either at the fundamental (1.054mm) or the second harmonic (0.527mm) wavelength as required for various laser plasma interaction studies.

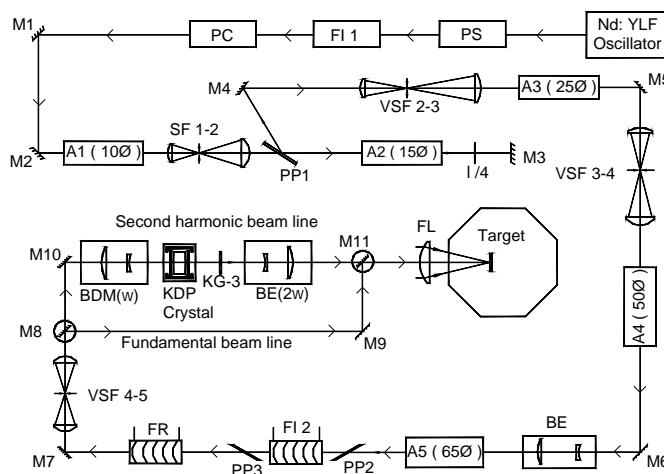


Fig L.18.1 Layout of the Nd:glass high power laser chain including frequency doubling set-up

A schematic diagram of the Nd:phosphate glass laser chain operated in 1.054mm and its second harmonic conversion set-up is shown in fig.L.18.1. A mode locked Nd:YLF oscillator operating in the TEM₀₀ mode provides a train of 0.5mJ/25ps laser pulses. After passing through a single pulse selector (PS) and an electro-optic pulse-cleaner stage (PC), the laser pulse is amplified by five stages of Nd:phosphate glass amplifiers (A1 to A5) of successively increasing laser rod diameters from 10mm to 65mm. One spatial filter (SF 1-2) and two vacuum spatial filters (VSF) cum image relay systems are placed in between different