KDP Q-SWITCHES AND SECOND HARMONIC GENERATOR FOR HIGH-POWER SOLID-STATE LASERS

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KDP electrooptic light modulators and optical second harmonic generators have been developed for high power solid-state laser applications. The device parameters and the results in switching and frequency doubling of Nd-glass lasers are reported.

1. Introduction

KDP (potassium dihydrogen phosphate) crystals grown from water solution are very suitable for high power laser applications because of their good optical quality, high resistivity to laser damage and large size available. Longitudinal Z-cut KDP electro-optic modulators are preferred to other modulators in Q-switching of high power solid-state lasers because of their high transmission ratio, large aperture and simple construction [1]. Although KDP crystals are characterized by medium nonlinear optic properties [2] they are widely used for frequency doubling of pulsed and CW Nd-YAG, Nd-glass, ruby and different dye lasers because of the advantages listed above and mainly the possibility of their room temperature phase matching.

2. Preparation of KDP samples

Optical quality KDP monocryals were grown by automatically controlled, slowly cooling (0, 3 °C/day) of water solution of “Optipur” grade MERCK KH₂PO₄ material from 50 °C to 30 °C. The double sheet thermostat was supplied with electronically controlled, programmable alternating mixing [3]. Two prisms of monocryals sized about 45 mm × 50 mm × 85 mm were obtained. Rectangular samples oriented optically were cut from the prisms for Q-switch and frequency doubling devices. The end faces of the samples were optically flat polished. The samples were selected by strain-optic, interferometric and light-scattering methods of optical test equipment KP-74 [4]. Mechanical and microscopic investigation of the dislocation structure was performed [5] on the crystal samples and their resistivity against laser damage was also investigated [6]. Strain free 0° Z cut crystal samples of 1000/cm² dislocation density and 1 GW/cm² damage threshold, measured by ruby laser, were used for large aperture longitudinal electrooptic modulators designed for Q-
switching of high power Nd-glass solid state lasers. 45° Z cut samples similarly treated were further oriented and sliced to obtain phase matched samples for optical second harmonic generation of Nd-glass radiation.

3. Investigation of longitudinal 0° Z KDP modulators

Some construction versions of 0° Z longitudinal KDP modulators were investigated. End-plate and stripe electroded modulator crystals were compared considering electric field characteristics of the electrooptic modulators as follows: the static and dynamic half wave voltages, the electric field distribution uniformity and the electric breakdown. The effect of mounting and mechanical clamping on the transmission distribution and the contrast ratio of the modulators was investigated.

20 mm × 20 mm aperture, 25 mm long 0° Z cut KDP samples supplied with copper plate electrodes with 15 mm diameter circular openings pressed by spring to the Z-faces of the sample were compared to the identically sized and oriented modulator crystals electroded with 4 mm width, 0.1 mm soft copper stripes rolled on the lateral faces at the optical windows. The results obtained for the half-wave voltages, the electric field uniformity and the contrast-ratio are summarized in Table I.

<table>
<thead>
<tr>
<th>Electrode</th>
<th>Clear aperture</th>
<th>Half-wave voltage [kV]</th>
<th>Field nonum</th>
<th>Contr. ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>static</td>
<td>dynamic</td>
<td>%</td>
</tr>
<tr>
<td>end-plate</td>
<td>15 mm diam.</td>
<td>14.1 ± 1</td>
<td>18.2 ± 2</td>
<td>16</td>
</tr>
<tr>
<td>stripe</td>
<td>20 mm × 20 mm</td>
<td>10.5 ± 1</td>
<td>15.3 ± 2</td>
<td>5</td>
</tr>
</tbody>
</table>

The half-wave voltages were determined by taking the transmission-voltage characteristics of the modulator crystals placed between crossed polarizers. The transmission was measured with 1 mm diameter He—Ne laser beam passing through the modulator in the middle of the aperture. To characterize the electric field nonuniformity the difference of the maximum and minimum half-wave voltage expressed in the percentage of the maximum one, i.e. the half-wave voltage measured in the middle of the aperture, was used. The half-wave voltage distribution was obtained by scanning the He—Ne laser beam across the aperture. The stripe-electrode construction proved to be more advantageous than the end-plate construction having less half-wave voltage and more uniform driving field and, consequently, a smoother transmission distribution [7]. Only the problem of electric breakdown at lower voltages arose because of the small electrode distance. To avoid the breakdown the length of the crystal can be increased or, as it was done in our experiments, the stripe electroded modulator crystal can be embedded in silicon rubber before mounting it in the polyamide house.