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Representation of CO_2 laser gain curve in optovoltaic signal*

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Some aspects of coupling-out hole mirror applications in optical resonators of optovoltaic stabilized CO_2 lasers are presented.

Total reflecting output mirrors with a coupling-out hole are applied to some constructions of high power lasers. The required value of output mirror transmittance can be easily obtained through the choice of coupling-out diameter [1]. This kind of mirror is particularly useful in the high power laser construction such as cw CO_2 lasers.

The stabilization of output laser power is necessary in some technological applications of cw CO_2 lasers. Detectorless methods of power stabilization, such as optogalvanic or optovoltaic ones [2, 3], can be used in order to avoid troublesome splitting of laser beam before its putting into servo-system. In these methods the effect of correlation between the populations of upper laser level of CO_2 molecule and of ionization levels of $CO_2:N_2:He$ gas mixture is used. Theoretical results indicate that the molecules of nitrogen play a main role in the energy transfer from lasing levels to ionization ones [4]. Owing to this effect the change of laser power inside an optical resonator (as well as output power) influences the value of voltaic drop across the discharge tube, i.e., optovoltaic signal (with stabilized laser current). The accuracy of optovoltaic representation of CO_2 laser gain curve is also confirmed by theoretical results.

In this paper we also show that above correlation between the optovoltaic signal and laser output power may be determined for the optical resonator equipped with an output mirror transmitting with its whole surface (e.g., Ge mirror) as well as for optical resonators with coupling-out hole mirrors (for the exact alignment of the resonator, only). It is, however, difficult to achieve the exact correlation for lasers equipped with coupling-out mirrors and operating in multi-transverse modes.

The experiment was carried out in an arrangement of optical resonator (107 cm long) equipped with a plane diffraction grating and a concave ($R=10$ m) totally reflecting mirror with a coupling-out hole of 2.5 mm-diameter. The coupling mirror could be replaced by a concave ($R = 10$ m) Ge mirror. The laser consists of discharge tube 60 cm long and 14 mm in diameter, ended with NaCl

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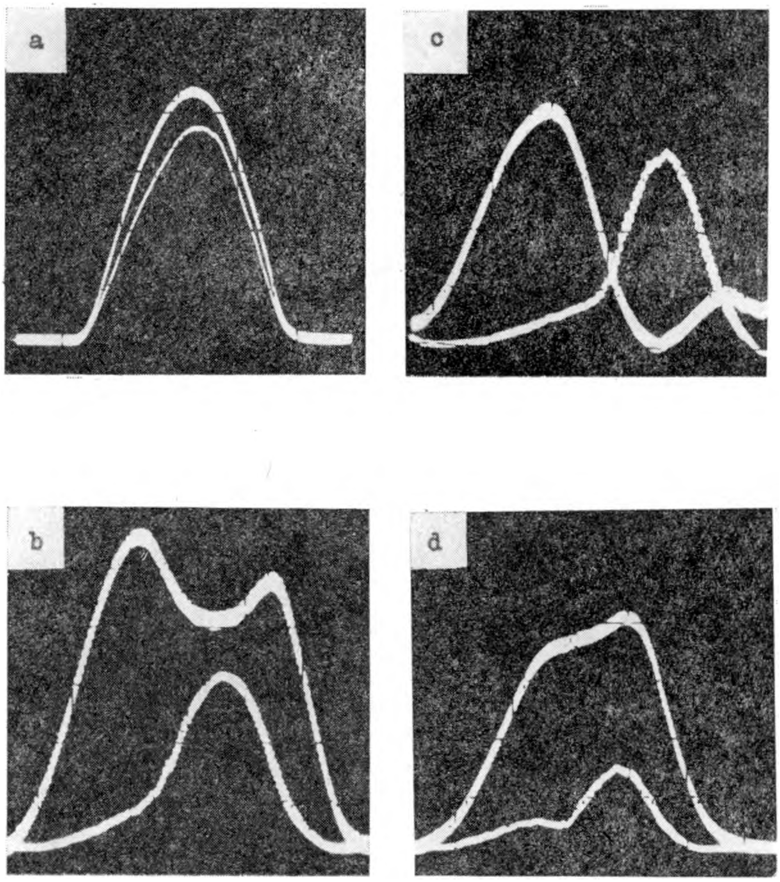
Brewster windows. The laser operated in sealed-off conditions. Optovoltaic signal was measured by switching on and off the laser beam inside the resonator by means of a chopper. In the experiment phase-sensitive detection method was used. The frequency of the laser was scanned through the width of its gain curve (about 70 MHz) using a piezoceramic transducer. Both the optovoltaic signal and laser output-power signal (monitored with CdHgTe detector) were simultaneously observed by means of a two-channel oscilloscope.

The figure shows examples of optovoltaic signal and output-power signal obtained for the constructed laser. Full correlation is observed when the laser was equipped with the Ge mirror (see Fig. a) When the laser was equipped with



Oscillograms of the CO_2 laser gain curve (lower curve) and its optovoltaic representation (upper curve): a – with Ge mirror, b, c, d – with coupling-out hole mirror

the coupling-out hole mirror and operated in multi-transverse modes the two profiles usually did not overlap (Figs. b and c). An accurate representation of output laser power in optovoltaic signal is also possible when the optical resonator is carefully applied with the coupling-out hole mirror (Fig. d). However, this state is not stable and practically useless for optovoltaic stabilization of laser power or its frequency.

Summing up, it should be admitted that the use of coupling-out hole mirrors in optical resonators of detectorlessly stabilized CO_2 lasers can be trublesome because of non-unique optovoltaic detection of the gain curve.

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Изображение кривой усиления CO_2 лазера в оптовольтаическом сигнале

Представлены некоторые аспекты применений выходных зеркал с отверстием в оптических резонаторах оптовольтаически стабилизированных CO_2 лазерах.