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Nonlinear Filter for $\lambda = 1.06$ μm

Nonlinear filters displaying a strong dependence of absorption on radiation intensity are widely applicable in laser technique.

Such filters appearing among other applications as passive Q switches of laser resonators should meet the following requirements:

— Absorption band of the filter should be situated within generation range of the laser.

— Absorption band width should be at least equal to the luminescence line width of the active laser material.

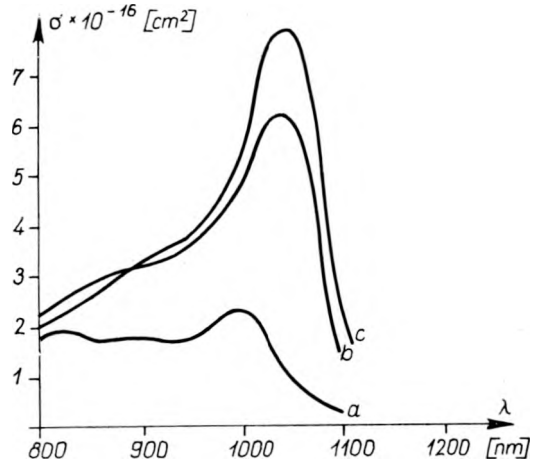

Fig. 1. Unitary absorption of the dye TE-25 solution in various solvents: *a* — in methanol, *b* — in nitrobenzene, *c* — in quinoline

— Deactivation time of the excited levels should be adequately short, for it decides on the generation time and influences peak power of the generated radiation.

Moreover, it should be a possibly stable composition.

Q switches of such a type have been applied for quite a long time to generation of gigant pulses in ruby lasers.

In our case organic dyes of phtalocyanite and carbocyanite class displaying absorption in the $\lambda = 0.6943$ μm range were used.

Essential difficulties have been encountered at synthesis of nonlinear dyes possessing absorption band shifted to $\lambda = 1.06$ μm, i.e. to the neodymium lasers absorption band. According to reports met in scientific literature these dyes are in most cases compositions not precisely specified and known mainly under trade names [1].

More detailed data are given by B. H. Soffer [2] and J. M. Grjaznow [3]. Compositions applied by these authors belong to carbocyanite and phtalocyanite classes. More interesting in consideration of the short deactivation time (10^{-10}s) is a dye denoted by symbol TE-25. It is thiopentacarbocyanite; the authors [2] used it for passive modulation of Q of neodymium laser in methanol solution. This filter displays several disadvantages, and among them:

— appreciable shift of absorption maximum in relation to the luminescence line of neodymium laser ($\lambda_{max} = 1.0$ μm);

— short life time (the dye in solution undergoes irreversible decomposition after about 3 hours).

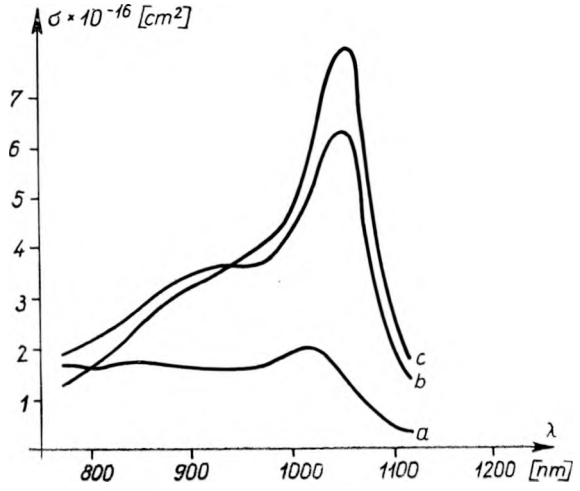

Fig. 2. Unitary absorption of the dye TE-26 solution in various solvents: *a* — in methanol, *b* — in nitrobenzene, *c* — in quinoline

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Construction of high power lasers and particularly of lasers working in configuration with self-synchronization of modes made it possible to undertake some endeavours of synthesis of the dye described by B. H. Soffer.

We have produced and subjected to examinations two types of carbocyanite dyes: equivalent of dye TE-25 and its halogen derivative obtained by substitution in extreme rings of meta-atom by chlorine. This dye has been designated by symbol TE-26.

The produced dyes underwent static examinations with particular attention to the course of spectral

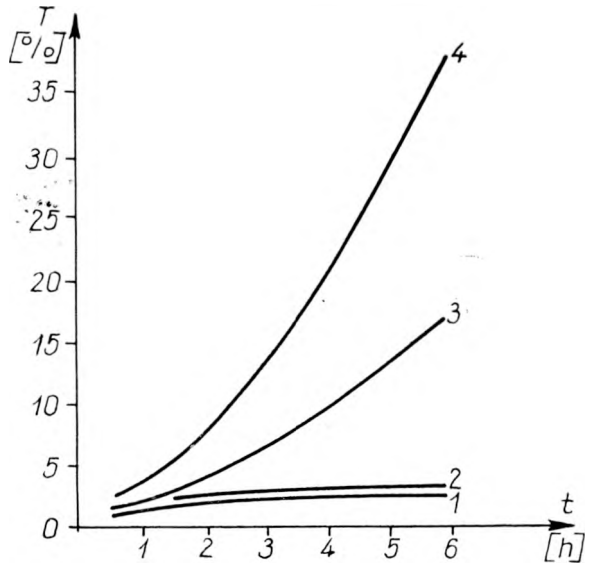

Fig. 3. Behaviour of the dye TE-25 in nitrobenzene in function of time: 1 and 2 — measurements in darkness, 3 and 4 — measurements in illumination $T_1 = T_3 < T_2 = T_4$

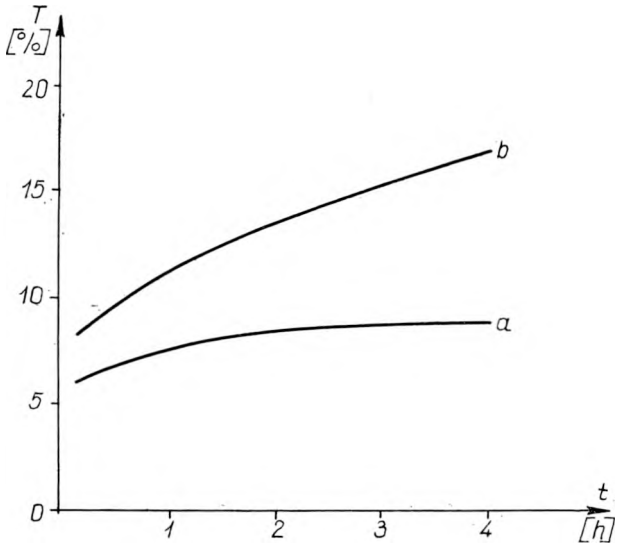

Fig. 4. Behaviour of the dye TE-25 in nitrobenzene

$a - T_{max}$ $b - T_{1060}$

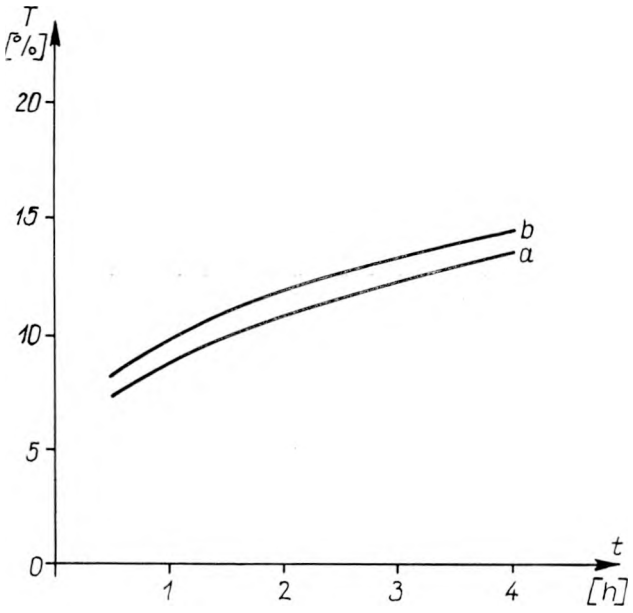

Fig. 5. Behaviour of the dye TE-25 in quinoline

$a - T_{max}$ $b - T_{1060}$

characteristics depending on the solvent as well as to the influence of external conditions on the life time of the life time the dye solution.

Methanol, nitrobenzene and quinoline have been applied as solvents.

In Fig. 1 and 2 the dependence of the molecule cross section of dyes TE-25 and TE-26 on various solvents has been shown.

Fig. 6. Monopulse of duration time $\tau_{1/2} = 20$ ns

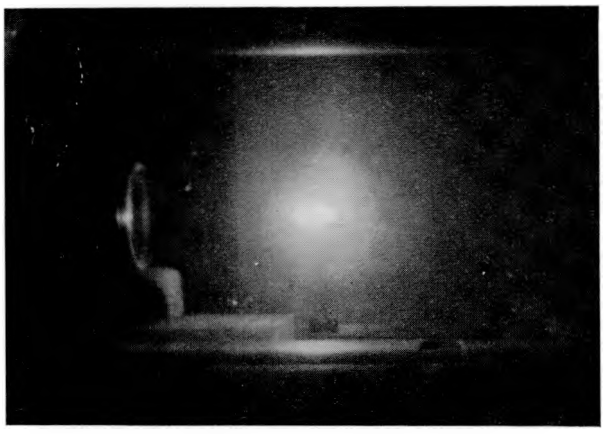

Fig. 7. The air ionization effect by concentrated laser radiation. Lens of focal length $f = 150$ mm

It can be seen that the type of solvent causes quite essential shift of the maximum of absorption spectrum and a change of unitary absorption.

The life time of dye is considerably influenced by its illumination, chiefly by the short-wave part of visual range spectrum. This is clearly evident from the graphs in Fig. 3.

Properly prepared nitrobenzene and quinoline solutions showed regular operation even during 48 hours.

In a monopulse laser pulse duration time of the order of 20 ns the peak power of about 200 MW (Fig. 6), sufficient to release the effect of ionization in air (Fig. 7) has been obtained.

The essential parameter of the dye, i. e. deacti-

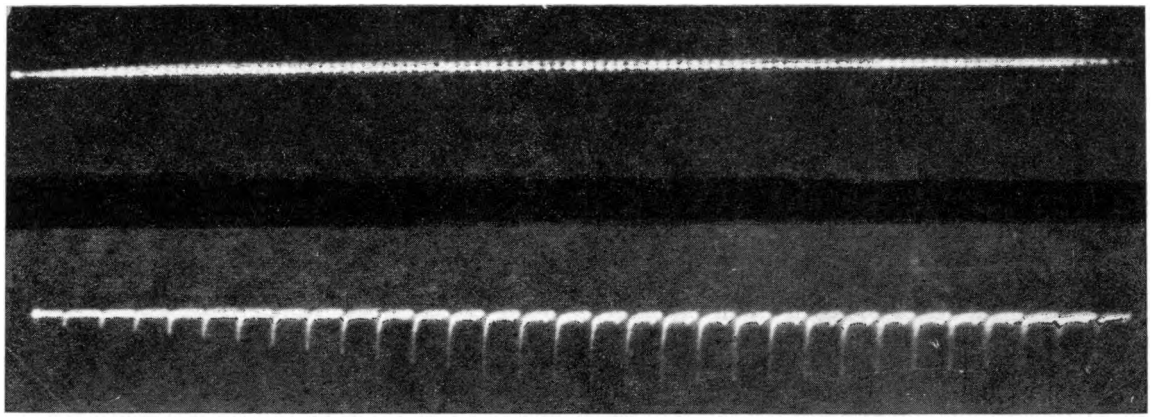

Fig. 8. Pulse train in arrangement with self-synchronization of modes. The upper path shows for comparison the 10 ns time markers

Decomposition of dye is accompanied by drift of absorption spectrum in the short-wave direction, the maximum absorption being preserved almost unchanged.

This phenomenon can be observed in methanol and nitrobenzene, but it does not occur in quinoline (graphs in Figs 4 and 5).

Solution of dye TE-26 in carefully purified nitrobenzene and kept in a closed vessel does not show any essential transmission changes within tens of hours.

This dye is the object of further investigations.

Results of the investigations obtained hitherto show that the dye life time is substantially influenced by the type of solvent, by illumination, and by the purity of both the dye and the solvent.

Both dyes have been applied for Q switching of neodymium laser generating monopulses as well as pulse trains (self-locking).

vation time of the excited level, has not been measured directly. However, it is sufficiently short to obtain generation in the system of self-sinchronization of modes (Fig. 8).

As results from indirect measurements and theoretical evaluations deactivation time is of the order of 10^{-10}s.

The nonlinear filters which have been produced and thoroughly examined will encourage scientific works concerning pulse generation from neodymium lasers.

References

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[2] Soffer B. M., Hoskins R. N., Nature 204, 276, 1964.

[3] Грязнов Ю. Н., Лебедев О. Л., Серебряков Б. А., Стариков А. Д., Швам Е. Н. ЖПС X, в.5, 1969.

[4] Лебедев О. Л., ОиС XXIV, 300, 1968.