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CO2 laser with stable-unstable cavity: Q-switch regime with active mirror

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Usually Q-switch pulses in CO_2 lasers is obtained by putting mechanical shutter inside laser cavity To avoid undesirable beam transformations the beam is to be focused inside laser resonator and shutter is to be put exactly in the focal plane[2] To overcome these problems we suggest to use active deformable mirrors as the modulating element - the bimorph one or/and "cylindrical"
In our Group we have developed water cooled mirrors based on semi-passive bimorph piezoelement These bimorph correctors were successfully used as an intracvity mirrors to control for the radiation of a CO_2 lasers [1] Another type of the active mirror to be installed as one of the mirrors of the laser resonator to produce Q-switch laser pulses was suggested to change the wavefront of the laser beam only in one direction by means a of single actuator (fig 1) The mirror itself is the rectangular copper plate One side of this plate is polished to the optical quality Piezoceramic column (actuator) is installed between the rib of rigidity (shown on fig 1) and mirror support The cooling system made of copper plate surrounded by the tube with cooling water is connected to deformable mirror through special thermo conductive pasta The deformation of the surface via applied voltage to piezoceramic column has the shape close to cone in one direction The amplitude of the deformation of the surface is 40 μ, for the aperture of the mirror 55 mm (long side of the rectangular) Thickness of the reflecting plate of such corrector - 4 mm First resonance frequency - 15 kHz

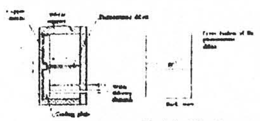
Fig 1 Deformable "cylindrical" mirror

In our first experiments with bimorph corrector we used Russian TL-5 laser [1] The measurement of the focused laser beam profile showed that along with the narrow kern, there exists rather high energy-intensive environment (pedestal) that contains more than a half of the total beam power The total divergence of the beam is approaching to 1 mrad The beam quality parameter of such laser beam is rather poor (~ 4)
That is why we have proposed and used a special scheme of the optical resonator It has the properties of an unstable telescopic resonator only in the plane perpendicular to the electrode walls, and it is stable in the plane parallel to these walls (Fig 2) The resonator includes two end mirrors, one of them is spherical and another is cylindrical The generatix of the cylindrical mirror is parallel to the electrode walls This resonator allowed to increase the far-field beam intensity by a factor of 2-3 in comparison with an ordinary telescopic resonator One of the very important advantages of the «stable-unstable» resonator is a good space coupling of the resonator and GDC volumes Only the lowest gaussian mode of the stable resonator was selected by diaphragm installed inside the cavity The principal mode size in our case was approximately 12 mm by $1/e^2$ level

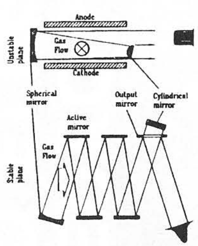

Fig 2 Stable-unstable resonator with unilateral beam output
Modified scheme

We substituted one of the folding mirrors with the cylindrical corrector (fig 2) Applying sine voltage to the actuator at the frequency 2 kHz we obtained the modulatiorf of the output radiation and received quasi Q-switch regime of generation - for the CW power 2 kW output intensity of the beam was 5 kW The duration of the pulses was 5 μc
The quality of the output beam, beam size and beam phase in the case of this kind of laser resonator and the use of active cylindrical corrector does not change because the modulation of the cavity parameters takes place only in the stable plane: in stable resonator the wavefront of the output beam coincides with the surface of the output mirror And this surface in our experiments was constant Some changes of the size of the beam in the stable plane inside cavity leads to the modulation of the intracavity losses but does not lead to the increase of the size of the output beam In the unstable plane of the resonator we did not change any parameters of resonator and so, no deformations of laser beam appear

1 *Laser Resonators: novel design and development* Alexis Kudryashov, Horst Weber, editors, SPIE Press, 301 p (1999)

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Increased brightness in pumping schemes using diode bars

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Diode bar curvature, also called "smile", is known to limit the brightness achievable in commonly used pumping schemes. A correction for this curvature would prove useful for side-pumped solid-state lasers or whenever the curvature of the pump beam causes a bad overlap with the intra-cavity beam [1] We show that by introducing a tilted, cylindrical collimating lens in front of the diode bar, the curvature of the diode's beam can be reduced, as shown in Fig. 1, and the beam quality increased by more than 100%. Moreover, when this correction mechanism is used in conjunction with a beam shaper [2], the total pump power of the set-up is increased because clipping of the pump power at the beam shaper is reduced due to better beam quality The basic mechanism is that the center part of the diode radiation in Fig. 1 becomes shifted more upwards than the more lateral parts of the radiation due to the thicker center part of the tilted lens

We used a 20-Watt diode bar emitting at 792 nm, configured with factory installed, AR-coated, cylindrical micro lens for collimation of the diode's fast axis This diode bar had a nearly quadratic curvature (smile) and was therefore well suited for correction with a cylindrical, plano-convex collimating lens which has a common spherical curvature on its convex surface. After inclining the slow-axis collimating lens we achieved a reduction of about 50 % in the curvature's peak-to-peak height immediately after the lens and the output power after the beam shaper increased by more than 27% from 14 Watt to 17 8 Watt The reduction of the curvature increased the pump beam quality by more than 100% as was verified by taking M^2 measurements with a CCD. The total M^2 dropped from $M^2_x \times M^2_y = 6720$ to $M^2_x \times M^2_y = 3200$ Due to the smaller divergence of the corrected pump beam we were now enabled to increase the distance between beam shaper and focusing lens, maintaining the same beam diameter on the lens, and obtained therefore a smaller focus, which was measured with the CCD. The corrected beam also showed a smooth top hat intensity distribution at the focus with equal quality factors in orthogonal directions The total calculated brightness increase was 120%

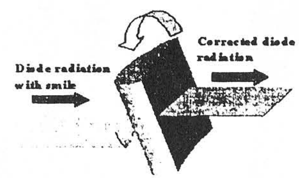

Fig 1: Scheme of the working principle of the inclined cylindrical lens

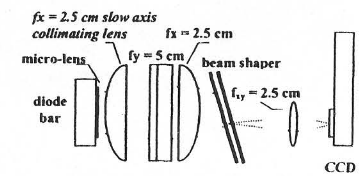

Fig 2: Set-up using the inclined slow axis collimating lens and a beam shaper

1 M Tikerpae, S. D. Jackson, T. A King, Opt Commun **167**, 283-290 (1999)
2 W A Clarkson and D. C. Hanna, Opt. Lett. **21**, 375-377 (1996).

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