Influence of neon and argon admixtures on laser generation conditions of krypton ion lasers

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In the paper we present research results on the phenomenon of advantageous influence of neon and argon admixtures on laser generation conditions of krypton ion lasers. We have noticed that small amount of neon or argon strongly increases the laser power of several krypton laser lines. We explain this phenomenon as result of various effects appears in discharge plasma of ion lasers. In our measurements were used high power gas ion lasers developed and manufactured in WUT.

We have observed that small admixture of argon and neon in krypton ion laser affects positively on laser generation conditions of several krypton laser lines. This manifests in the laser power growth of several krypton lines in presence of argon and much stronger in presence of neon (fig. 1). It has to be added that the total mixture pressure was maintained on the fixed value so the quantity of krypton in mixtures was reduced. Especially surprising is the twofold power growth of 520 nm line for mixture with krypton quantity reduced to about 50-70%. For some laser lines argon and neon additions have no positive influences as well as krypton additions for all argon laser lines (fig. 2). The other observed effect is the change of the laser generation threshold current (fig. 3). The decrease of threshold discharge current in presence of admixtures appears for these laser lines for which the power growth were observed. It means that presence of argon or neon in krypton discharge positively affects laser generation conditions of these laser lines. Described phenomenon is opposite to the obvious supposition that reduction of the quantity of laser gas (in our example krypton) in mixture with maintained total gas pressure should leads to decrease the laser power value of all laser lines.

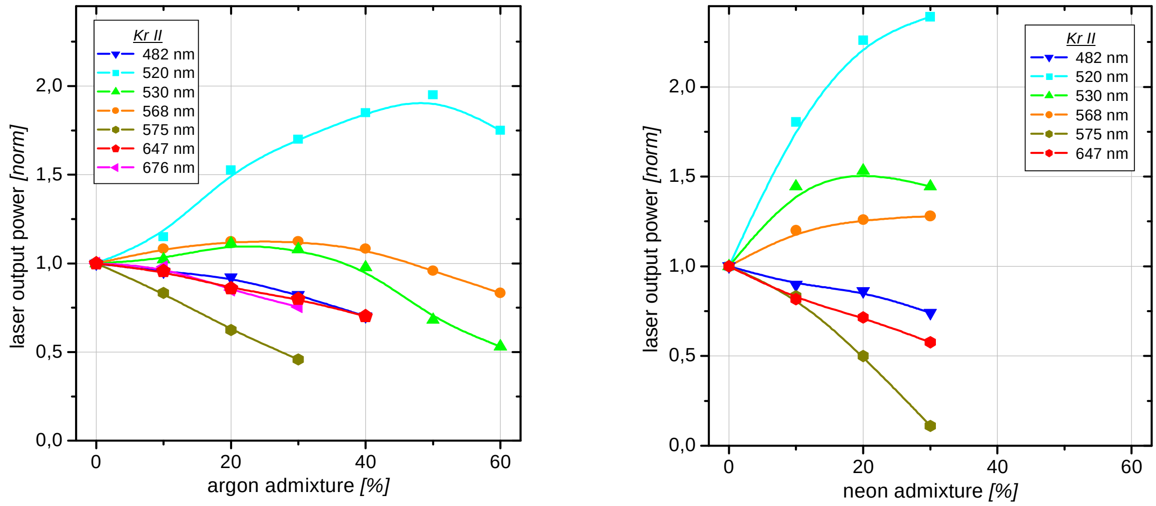

Fig. 1: Influence of argon (on left) and neon (on right) admixtures on laser power of krypton lines. Total gas pressure 200 mTr. Discharge current 40 A. Values normalised to values for pure krypton.

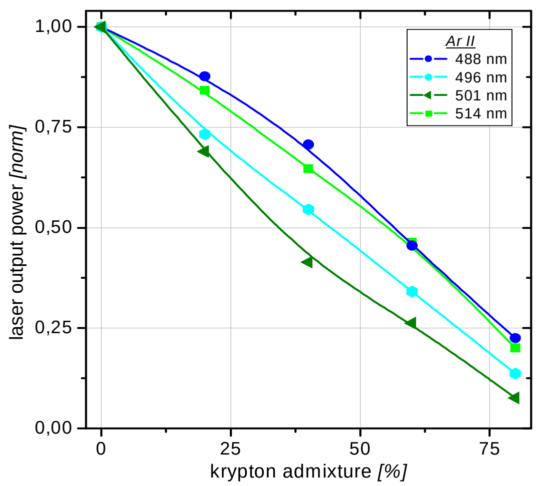

Fig. 2: Influence of krypton admixtures on laser power of exemplary argon lines. Total gas pressure 200 mTr. Discharge current 40 A.

We consider that described below phenomena in the arc discharge plasma affect mostly laser generation conditions in noble gas mixture.

Admixtures of gas with higher ionisation energy increases the electron temperature of discharge plasma. This increases the excitation efficiency of upper laser levels which leads to the laser power increase [1]. However admixture of other gas decreases the amount of laser gas so the atoms and ions concentration of laser gas in discharge plasma decreases too. This should leads to decrease the laser power too. Because both phenomena have opposite directions there must be the optimum admixture composition in point of view the laser power. The other known phenomenon in arc discharge is the increase of the electron temperature of plasma as consequence of gas pressure decrease [2]. Similarly to the phenomenon described earlier this effect should affects the laser power. However like as above, the negative consequence is the decrease of the concentration of laser gas ions and atoms. Our thesis is that described above phenomena could be related together. The positive influence of argon/neon additions on the laser power can be noticed for this krypton laser lines for which the positive effect of electron temperature increase is stronger than negative effect of the ion concentration decrease. This thesis we have verified experimentally. On fig. 4 we present measured influence of krypton pressure on the laser power of krypton lines. Measurements were performed for wide range of pressures – also for pressures far from values in typical commercial lasers. Analysing the chart it can be noticed that the stronger influence of argon admixtures on the laser power appear for these laser lines which laser power in pure krypton shows quickest drop with gas pressure increase. Results for argon and neon (fig. 1) show that influence of neon admixtures (gas with higher than argon ionisation energy) on the laser power of krypton laser lines is much stronger than argon ones. It can prove that our thesis is true. The next phenomenon which could be taken into account is the gas pumping effect which is generally disadvantageous for laser generation [3]. It causes to move some amount of gas into the direction of one of discharge tube ends (the direction depends on laser tube construction). The efficiency of this effect is higher for argon and neon than for krypton. As consequence more quantity of argon or neon than krypton will be removed from the discharge region. So mixture remained along the discharge capillary will be richer in krypton.

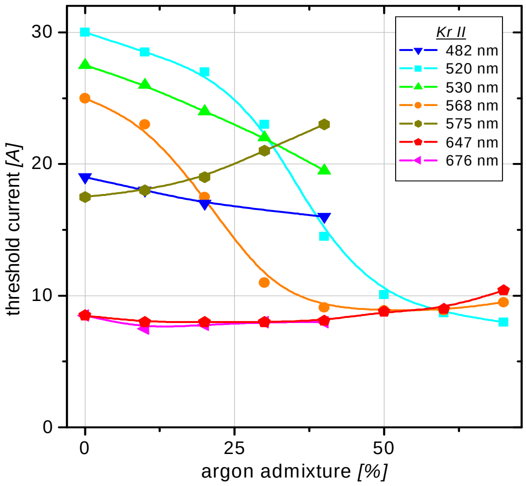

Fig. 3: Influence of argon admixtures on laser generation threshold current. Total gas pressure 200 mTr.

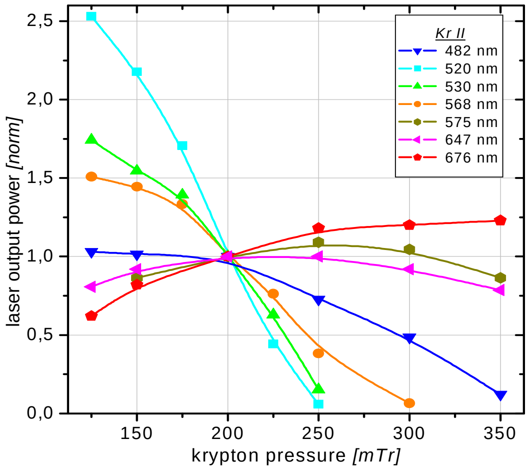

Fig. 4: Influence of krypton pressure on the power of krypton laser lines. Measurements was performed in pure krypton. 40 A discharge current.

It must be pointed that in commercial ion lasers it is not possible to fill discharge tubes with gas pressure lower than about 200mTr. Filling the laser tube with lower pressures is dangerous and may lead to non-reversible destruction of tubes. Additions of neon or argon as buffer gas could be the proper way to increase the power value of several laser lines in krypton ion lasers with maintaining the total gas pressure on safe level.

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References

[1] S.A.Ahmed, *Parametric and discharge studies of three-color gas mix ion lasers*, J.Appl.Phys., Vol. 45, No. 1, 1974.

[2] R.J.Bickerton, A.von Engel, *The positive column in a longitudinal magnetic field*, Proc. of Phys. Soc. B, vol.69, p.468 (1956).

[3] A.N.Chester, *Gas Pumping in a discharge tube*, Phys. Rev., 169, nr 1, 172 (1968).