2) medical laser systems based on the ability to control tissue penetration depth via wavelength tunability;

3) testing of low-loss fluoride-fibers at 2550 nm may be achieved by optimization of the cavity mirrors to extend the laser tuning range.

REFERENCES

1. L.F.Johnson, R.E. Dietz, and H.J. Guggenheim, "Spontaneous and stimulated emission from Co^{2+} ions in MgF_2 and ZnF_2," Appl. Phys. Lett., 5, pp.21–22, 1964.
2. P.F. Moulton, "An investigation of the Co:MgF_2 laser system, IEEE. J. Quant. Electron., QE-21, pp. 1582–1595, 1985.
3. P.F. Moulton, "Pulse-pumped operation of divalent transition-metal lasers," IEEE. J. Quant. Electron., QE-18, pp. 1185–1188, 1982.
4. M.G. Knights and P.F. Moulton, "Broadly tunable laser operation of thermoelectrically cooled Co:MgF_2," Paper THM2, 1987 Conference on Lasers and Electro-optics, Baltimore, Md.
5. D. Welford and P.F. Moulton, "Room-temperature operation of the Co:MgF_2 laser," Paper ME5, 1988 Conference on Lasers and Electro-optics, Anaheim, Calif.

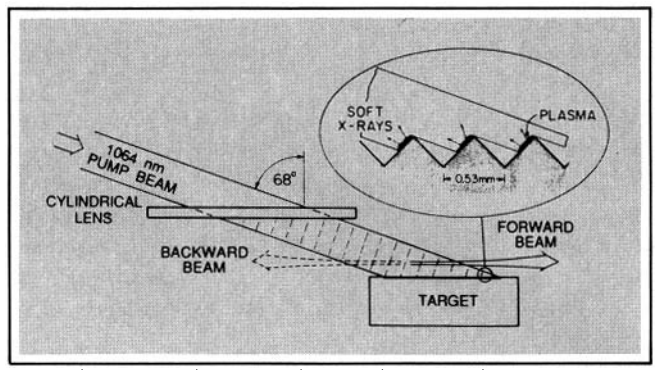
TRAVELING-WAVE GEOMETRY FOR SHORT WAVELENGTH LASERS

STEVE HARRIS AND J.F. YOUNG
DEPARTMENT OF ELECTRICAL ENGINEERING
AND APPLIED PHYSICS
STANFORD UNIVERSITY
STANFORD, CALIF.

Stanford researchers have demonstrated a new pumping geometry that promises to be a significant step in the development of practical photoionization-pumped short-wavelength lasers. Using this method, they have observed single-pass, fully saturated gain near 100 nm in both Xe and Cs.[1,2]

Work in recent years has shown that laser-produced plasmas are a useful source of incoherent soft x-rays for pumping potential extreme ultraviolet (XUV) laser systems. Most of these experiments have used a simple line focus that results in simultaneous excitation along a path length of several cm. Studies of the Xe auger system, however, show that competing processes limit the practical gains to about 4 cm^{-1}; higher excitation levels do not produce higher gain coefficients. Theoretically, it seems likely that similar limits will occur in other atomic systems, so that large total gains, and thus true laser action, can only be achieved using long excitation lengths.

The upper-level lifetime of many XUV transitions, however, is short compared to the time required for light to travel over a long excitation region, reducing the effectiveness of the pumping. The Stanford workers solved this problem by using a traveling-wave laser-produced plasma



Traveling-wave laser-produced-plasma soft x-ray source.

excitation. The primary 1064 nm laser is incident upon a cylindrical lens at about 70° from normal and is focused onto a metal target that is parallel to the lens (see figure). The large angle of incidence expands the length of the line focus by nearly a factor of 3, to 9 cm and 17 cm in the Xe and Cs experiments, respectively. More importantly, the pump laser sweeps across the target at nearly the speed of light, and the emitted soft x-rays thus provide synchronous traveling-wave excitation of the ambient gaseous medium.

Grooves were cut into the target surface to decrease the local angle of incidence of the pump beam, reducing reflection. In addition, the grooves divide the input beam to form many small, separated plasmas rather than one continuous line. The sum of the projected length of these plasma spots is approximately equal to the input beam diameter, meaning that no increase of laser energy is required to excite the much longer length.

The new geometry was initially used to excite the Xe III 109 nm Auger transition.[1] A 3.5 J, 300 psec, 1064 nm pump beam, 3.3 cm in diameter, was focused to an intensity of $2 \times 10^{11} W/cm^2$ over a 9 cm length of target in an ambient Xe pressure of 4 Torr. Small-signal gain was determined by measuring the time-integrated emission as a function of excitation length. A simple exponential fit to the data yields an average gain coefficient of 4.4 cm^{-1}. Thus, unsaturated amplification along the full 9 cm of length provides a total gain of exp (40), or 170 dB. In comparison, the first observation of gain in the Xe system was made at LLNL[3] using a 9 cm normal-incidence line-focus geometry; there, a 55 J, 1 ns pump laser produced a total gain of exp (7.2).

In recent work, a related grating corrected and exactly synchronous geometry was used to pump a 96.6 nm laser in Cs. The upper level of this laser is embedded in the continuum of the valence electron and autoionizes in about 60 psec. The traveling-wave geometry allows a pumping rate that is sufficiently rapid that the stimulated

rate exceeds the autoionizing rate. Here, an extrapolated small signal gain of exp (83) (4.9 cm^{-1} over 17 cm) is observed.

REFERENCES

1. M.H. Sher, J.J. Macklin, J.F. Young, and S.E. Harris, "Saturation of the Xe III 109 nm laser using traveling-wave laser-produced-plasma excitation," Optics Lett. 12, 891–893, Nov. 1987.
2. C.P.J. Barty, D.A. King, G.Y. Yin, K.H. Hahn, J.E. Field, J.F. Young, and S.E. Harris, "A 12.8 eV laser in neutral cesium," Phy. Rev. Lett. (to be published).
3. H.C. Kapteyn, R.W. Lee, and T.W. Falcone, Phys. Rev. Lett. 57, 2939, 1986.

NONLINEAR OPTICS

PHOTOREFRACTIVE NONLINEAR OPTICS

POCHI YEH
ROCKWELL INTERNATIONAL SCIENCE CENTER
THOUSAND OAKS, CALIF.

Bird-Wing phase conjugators

A new mutually pumped phase conjugator (MPPC) was discovered at the Rockwell International Science Center. This conjugator is called Bird-Wing Phase Conjugator (BWPC) because the beam path inside the crystals bears resemblance to a pair of bird wings.[1]

When two mutually incoherent laser beams are incident upon opposite *a* faces of a $BaTiO_3$ crystal, a pair of phase-conjugate beams is generated. The spatial wavefronts of the beams are conjugated and the temporal information is exchanged. The phase conjugation requires the simultaneous presence of both beams. It was discovered that the rise time of mutually pumped phase conjugation using the Bird-Wing configuration is significantly shorter than that of other self-pumped phase conjugators. Similar conjugators with Frog-Leg configuration were also observed in SBN crystals. Such new phase conjugators are far better suited for optical communication applications than are conventional conjugators. Three models can explain the phenomenon of mutually pumped phase conjugation in photorefractive crystals: self-oscillation,[2] resonator model,[3] and hologram sharing.[1,4]

Phase-conjugate Sagnac interferometers

A new type of phase-conjugate interferometer was conceived[5] and demonstrated,[6] using the Bird-Wing phase conjugator described above. In the new interferometer, one of the mirrors of a conventional Sagnac ring interferometer is replaced with a BWPC. Such an interferometer has the dual nature of Michelson and Sagnac interferometry. As far as wavefront information is concerned, the BWPC acts like a retro-reflector and the setup exhibits phase-conjugate Michelson interferometry and optical time reversal.[7] As for the temporal information, the BWPC acts like a normal mirror and Sagnac interferometry is obtained. This new phase-conjugate interferometer can be used to perform parallel image subtraction over a large aperture. When optical fiber loops are inserted in the optical path, fiber-optic gyros can be constructed for rotation sensing.[8]

REFERENCES

1. M.D. Ewbank, Opt. Lett., 13, 47, 1988.
2. M. Cronin-Golomb, B. Fischer, J.O. White, and A. Yariv, IEEE J. Quantum Electron., QE-20 12, 1984.
3. P. Yeh, T.Y. Chang, and M.D. Ewbank, J. Opt. Soc. Am., B 5, 1743 (1988).
4. P. Yeh (manuscript submitted to Opt. Lett.).
5. S. Weiss, S. Sternklar, and B. Fischer, Opt. Lett. 12, 114, 1987.
6. I. McMichael, P. Yeh, and M.D. Ewbank, Conference on Lasers and Electro-optics Technical Digest Series 7, 134, 1988.
7. M.D. Ewbank, P. Yeh, M. Khoshnevisan, and J. Feinberg, Opt. Lett., 10, 282, 1985.
8. I. McMichael, P. Beckwith, and P. Yeh, OSA Annual Meeting 1988, FY3.

RESEARCH IN NONLINEAR POLYMER MATERIALS AND DEVICES

D. RASKIN AND J.B. STAMATOFF
HOECHST CELANESE RESEARCH DIVISION
SUMMIT, N.J.

Over the past few years there has been a growing awareness of the potential benefits that could be gained from forming organic electro-optic units into polymers. The hope has been that, when compared to organic and inorganic crystals, new degrees of fabrication freedom and tractability could be attained in the polymeric form, while retaining the high electro-optic activity, fast response speed, and high optical damage resistance of the organic moieties.