LA-UR- 98-3549

Approved for public release;
distribution is unlimited.

CONF-9810113--

Title: USING OPTICAL PARAMETRIC OSCILLATORS (OPO) FOR
WAVELENGTH SHIFTING IR IMAGES TO VISIBLE
SPECTRUM

Author(s): Dustin Numkena, P-23
Thomas E. McDonald, Jr., P-23
Jeremy Payton, P-23
George J. Yates, P-23
Paul Zagarino, Sharpenit

Submitted to: International Advanced Studies Institute (IASI) Symposium on
"Detection and Analysis of Sub-surface Objects and Phenomena"
Monterey, CA; October 19 - 23, 1998

RECEIVED
APR 13 1999
OSTI

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

MASTER

Los Alamos
NATIONAL LABORATORY

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the U.S. Department of Energy under contract W-7405-ENG-36. By acceptance of this article, the publisher recognizes that the U.S. Government retains a nonexclusive, royalty-free license to publish or reproduce the published form of this contribution, or to allow others to do so, for U.S. Government purposes. Los Alamos National Laboratory requests that the publisher identify this article as work performed under the auspices of the U.S. Department of Energy. Los Alamos National Laboratory strongly supports academic freedom and a researcher's right to publish; as an institution, however, the Laboratory does not endorse the viewpoint of a publication or guarantee its technical correctness.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Using Optical Parametric Oscillators (OPO) for Wavelength Shifting IR Images to Visible Spectrum

Thomas E. McDonald Jr., Dustin M. Numkena, Jeremy Payton
George J. Yates
Los Alamos National Laboratory

Paul Zagarino
Sharpenit

ABSTRACT

We have carried out preliminary investigations into coherent imaging using Optical Parametric Oscillators (OPO) for wavelength conversion of near IR images to visible spectrum. A nonlinear crystal, second harmonic generator (SHG), was used for degenerate optical parametric up-conversion. A Potassium Titanyl Phosphate (KTP) doubling crystal was used to convert incident 1540nm flux to 772nm. Experiments included investigation of spatial resolution and responsivity of the OPO. Spatial resolution of 1.3 lp/mm was attained in both horizontal and vertical axis. Measured responsivity for this OPO configuration compared well with that attained from image intensifier-based systems. Equipment used for this experiment included an ORION SB2-2R pulsed solid state laser used as a light source and a CCD camera and frame grabber to capture and record all data. The experiment and results are discussed.

BACKGROUND

Imaging in the near IR is a goal of some projects that are being carried out at the Los Alamos National Laboratory under the joint Department of Energy and Department of Defense technology development program. Such a capability is useful in a number of applications including LADAR and range gated imaging. We have specifically been investigating range gated imaging in the region of 1.5 microns wavelength, where the eye damage threshold is 3 to 4 orders of magnitude higher than that at the shorter wavelengths from about 1.2 microns into the visible (Ref. 1).

The fundamental difficulty in imaging at 1.5 microns is the lack of photocathode materials that can detect 1.5-micron photons. Whereas photocathode materials have been developed that can detect photons over the wavelength range of approximately 100 to 1200 nm (Ref.2), the energy in a 1.5 micron photon is too low to stimulate photoemission in currently available photocathode materials. Alternate detection approaches must be found if imaging is to be possible at the 1.5 micron wavelength. One possible approach that has been developed with a degree of success is referred to as transferred electron (TE) photocathode, which was conceived and patented by Bell in the 1970's (Ref. 3) and within the past few years further developed by Intevac Advanced Technology Division of Santa Clara, CA. (Ref. 4) Although details of the Intevac development are proprietary, basically the transferred electron photocathode approach uses an externally applied electric field to increase the energy level of excited electrons sufficiently to escape into the vacuum region of the intensifier.

We have conducted several range gated imaging experiments using visible wavelength photocathodes (Ref. 5). Our earlier unpublished studies investigated the use of the Intevac TE photocathode intensifier in a planar diode configuration coupled to our own high speed stripline image intensifiers (Ref. 6). This combination would exploit the IR sensitivity of the TE photocathode and the fast shuttering capabilities of the stripline geometry intensifiers.

An alternate approach that is being considered by us at Los Alamos is the use of nonlinear optical crystals to double the frequency (or half the wavelength) of the 1.5 micron return signal to produce a signal in the region of 750-nm that can be detected by conventional photocathodes or CCD cameras. This approach of frequency doubling, or second harmonic generation, is commonly used to produce the second or third

EXPERIMENTAL RESULTS

Images were taken of the frequency doubled laser beam with the Cohu CCD camera and recorded using a Big Sky frame grabber. The recorded images are shown in Fig. 2a and 2b. The bar pattern used in these images had approximately 1.3 line-pairs/mm. Fig. 2a is taken with the lines running in a direction horizontal to the camera and Fig. 2b is taken with the lines running vertical to the camera. Although we observed fringe patterns in the images, spatial modulation is definitely maintained.

Fig. 2a

Fig. 2b

Fig. 2 Image recorded by camera of Laser beam after the second harmonic generator crystal (1.54mm--772nm). Spatial frequency of the line pattern is 1.3 lp/mm. Figure 2a is with the pattern in the horizontal orientation and Figure 2b is with the pattern in the vertical orientation.

CONCLUSIONS

It appears that spatial modulation is maintained through the nonlinear crystal conversion process; however, a great deal of fringing and some distortion is present. Our next step in the assessment is to examine imaging at a low flux level and determine the lower practical bounds of the process.

REFERENCES

1. David Sliney and Myron Wolbarsht, *Safety with Lasers and Other Optical Sources-A Comprehensive Handbook*, 1980 Plenum Press, NY
2. I. P. Csorba, *Image Tubes*, Howard W. Sams & Co., Inc.,
3. R. L. Bell, Long-wavelength Photoemission Cathode, Patent Number 3,958,143
4. K. A. Costello, G. Cavis, R. e. Weiss and V. W. Aebi, Transferred electron photocathode with greater than 5% quantum efficiency beyond 1 micron, SPIE Proceedings, Vol. 1449, P. 40-50, March 1991.
5. J. Payton et al, "Range Gating Experiments Through A Scattering Media", ISIA Conference on Detection And Analysis of Subsurface Objects and Phenomena, High-Speed Imaging Techniques and Applications Session, Naval Post Graduate School, Monterey, Ca., October 19-23, 1998.
6. M.C. Thomas., G.J. Yates, and P.A. Zagarino, "Fast Optical Gating Using Planar-Lead MCPs and Linear Microstrip Impedance Transformers," SPIE Vol. 2273-26, Ultrahigh-and High-Speed Photography, Videography, and Photonics Conference, San Diego, Ca., July 24-29, 1994.