Final Technical Report for Project Entitled
"PIN Diode Array X-Ray Imaging" (DE-AS08-87DP10685)

J.G. Jernigan

Space Sciences Laboratory, University of California, Berkeley

We have completed the construction of an X-ray camera based on a solid state imaging device and have obtained images of Omega laser targets. The new project is an evolution of a prior successful NLUF project (contract DE-AS08-85NV10507) based a smaller 10 X 64 Ge diode array. The new project is based on a Silicon, (Si), PIN diode array. The assembly is mounted in a cryogenically cooled, vacuum housing. Each Si diode has near quantum X-ray detection efficiency between 1-10 keV and a dynamic range of 10^3 in this energy band. The main objective of the project was to continue the investigation into the practical use of a PIN diode array readout device as a method of obtaining images of 1 to 20 keV X-ray emission from laser targets. The experiment has successfully demonstrated the feasibility of using a PIN array detector as a means of obtaining hard X-ray images in the high powered laser environment. We also demonstrated the capability of the detector to obtain real time images of the X-ray emission from laser targets. (F.J. Marshall, J.G. Jernigan, J.F. Arens, T. Collins, and G. Pien, 1992)

A PIN diode array was selected as the detector because of its broad range of X-ray sensitivity and history of successful use in discrete form in laser fusion research. The detector, developed at the Carlsbad Research Facility of the Hughes Aircraft Company, consists of a Silicon (Si) PIN diode array which is bump bonded to a single solid state device which contains an array of 256 x 256 ultra low-noise readout amplifiers. Each PIN diode has near quantum efficiency over the entire energy range 1 to 20 keV. This efficiency at the highest energies is a major advantage of PIN diode detectors over CCDs. As such it is the most sensitive instrument in this full energy range. The particular array used for these experiments has pixels of 30 μ m size. With magnification, X-radiation from laser plasma targets can be spatially resolved to 6 microns.

The instrumentation which is required to operate the PIN camera on the Omega target chamber consists of a pinhole camera assembly, cryogenic cooling supply and readout electronics. The PIN diode assembly is contained in a vacuum housing which is attached to the exterior of a pinhole camera support via a gate valve connection. A supply line runs from the main chamber liquid nitrogen tank to the detector housing enabling operation at cryogenic temperatures. A shielded cable runs from the detector to an electronics rack which is shielded from electromagnetic interference (EMI). The EMI rack contains the electronics which converts the analog readout signals into digital form. The digital information is subsequently transferred to a computer workstation where it is displayed in image form and stored as a binary file. A thin piece, (25 μ m), of tantalum, into which has been placed an array of pinholes, is positioned between the target and the detector completing the X-ray camera.

We have demonstrated the capability to make instantaneous X-ray images of laser targets in the interactive work environment of a high power, high repetition rate ($\sim 1/2$ hr), laser such as the Omega UV system. With this hybrid device, real time evaluation of X-ray images is possible. Quantitative real time X-ray imaging will also aid in the detailed analysis of laser target X-ray emission.

This project was carried out by the principal investigator Dr. Garrett Jernigan of the Space Sciences Laboratory of the University of California, Berkeley California and co-experimenter Dr. Frederic J. Marshall of the Laboratory for Laser Energetics of the University of Rochester. The results from the successful use of the X-ray camera are presented in a publication (Marshall et.al. 1992). A copy of this publication is attached as part of this report.

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.

We specifically thank Greg Pien for assistance in installing the X-ray camera on the OMEGA tank. The construction of the X-ray camera for laser fusion research was funded by DOE as part of the NLUF program (contract DE-AS08-85NV10507).

References

A PIN Diode X-Ray Camera for Laser Fusion Diagnostic Imaging, J.G. Jernigan, Frederick J. Marshall, John F. Arens, Michael C. Peck, Stephen D. Gaalema, Final Technical Report DE-AS08-85NV10507, April 1987.

Measuring Laser-Plasma X-ray Emission Using Photodiode Arrays, F.J. Marshall, J.G. Jernigan, J.F. Arens, T. Collins, and G. Pien, 1992, *Rev.Mod.Instr.* 63(10), 5094-5096