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FINAL REPORT

"Experiments on the Interaction of Intense Femtosecond Radiation with Dense Plasmas"

LLNL Subcontract No. B321297

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Dr. Michael Campbell

DISCLAIMER

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ABSTRACT

An upgraded KrF^* (248 nm) system producing a pulse energy of ~ 400 mJ, a pulse width of ~ 220 fs, and focal intensities above 10^{19} W/cm^2, has been constructed, tested, operated, and used in experimental studies. The spatial morphology of channeled radiation in plasmas has been measured with a spatial resolution of ~ 30 μm and damage studies of fused silica indicate that femtosecond (200 - 300 fs) 248 nm radiation has a damage limit not exceeding ~ 50 GW/cm^2, an unfavorably low level.

I. DISCUSSION OF RESULTS

A. ADVANCED KrF^* (248 NM) SOURCE

The preamplifier upgrade was installed, tested, and operated. With this new unit, total output pulse energies exceeding 400 mJ have been produced, a substantial improvement over the earlier capability.

The pulse width was measured with the new system with the TPF method in fused silica. The result gave a FWHM for the pulse width $\Delta t = 220$ fs, as shown in Fig. (1).

Focal spot measurements with f/3 optics indicate that a focal spot in the range of 2 - 3 μm can be produced. Hence, this system produces intensities well in excess of 10^{19} W/cm^2.

B. CHANNEL SPATIAL MORPHOLOGY

The role of plasma Raman scattering has been studied, since it could influence the production of X-rays in the channel. The results are described in Appendix B. Figure (1) of Appendix B illustrates the channel morphology ($\sim$ 100:1 aspect ratio) with a limiting resolution of $\sim$ 30 μm.

C. FUSED SILICA DAMAGE

Fused silica is a poor window material for femtosecond KrF^* (248 nm) radiation, either from the standpoint of damage or self-phase modulation. We find that a distinct nonlinear interaction develops at $\sim$ 50 GW/cm^2 which gives color center formation. The measured transmission characteristics, shown in Fig. (2), indicate this rapid onset. For comparison, the considerably improved properties of CaF_2 are also shown.

II. CONCLUSIONS

The upgraded system performs as expected and we have begun to explore a new field of phenomena associated with dense plasmas.

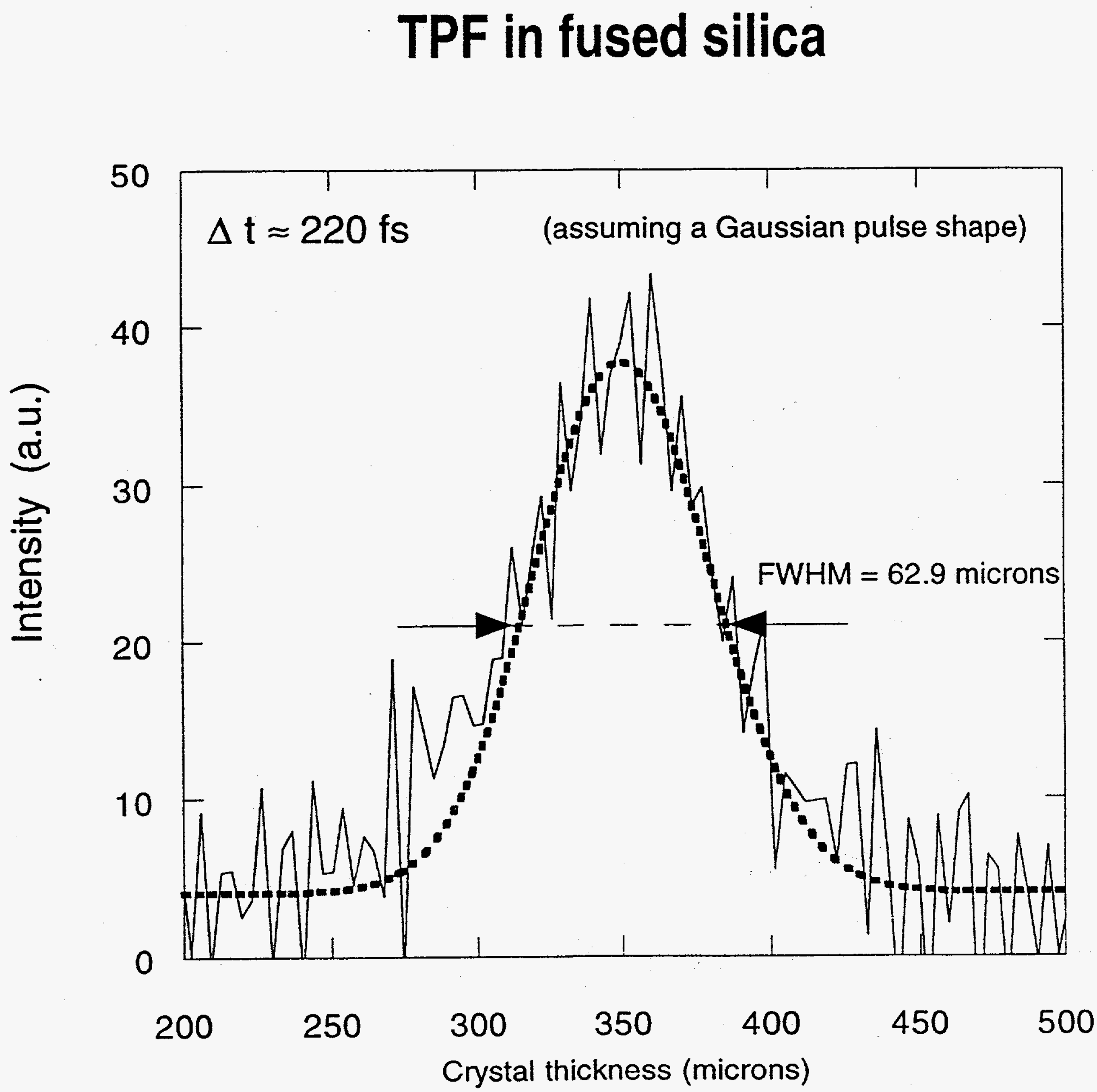

Fig. (1): KrF* (248 nm) source pulse width measured with upgraded amplifier by the TPF method in fused silica.

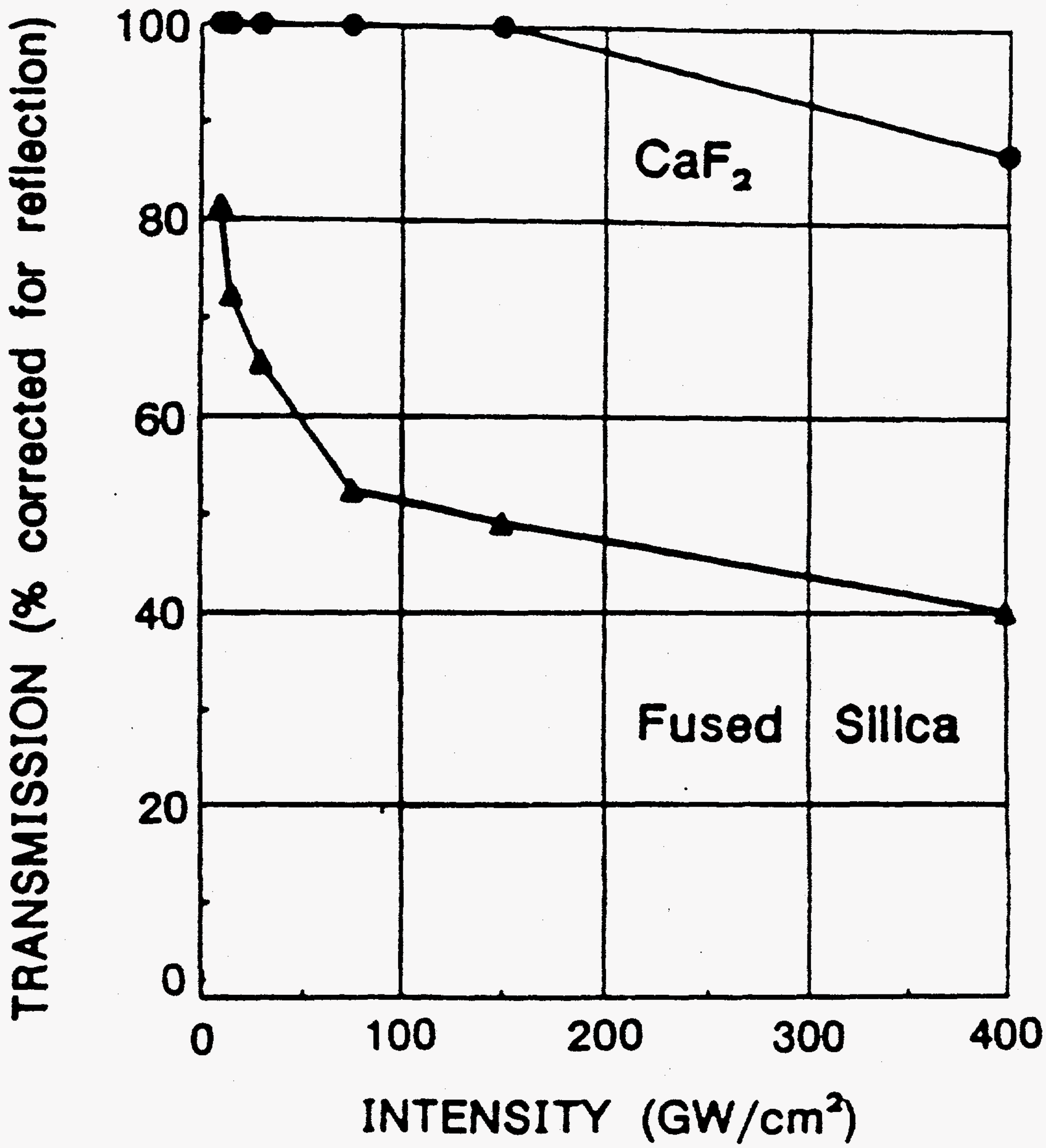

Fig. (2): Transmission of CaF_2 and fused silica of 248 nm radiation against increasing incident intensity.

III. APPENDICES

APPENDIX A: Statement of Work (Revised)

Statement of Work (Revised)

Irradiance Measurements

The Subcontractor shall install and characterize an advanced femtosecond KrF laser for experiments on the interaction of intense femtosecond radiation with dense plasmas. The Subcontractor shall perform irradiance measurements of the laser system, producing over 10^{19} W/cm^2. The Subcontractor shall measure the surface and bulk damage threshold of fused silica at a pulse duration between 100 and 300 fsec. Perform measurements of the spatial morphology of the X-ray emission from a self-trapped channel containing Xe clusters with a spatial resolution of $\sim$ 30 μm.

The Subcontractor shall generate a final report detailing and discussing the laser system characterization and data on the cluster experiments.