(Cd,Mn)Te Detectors for Characterization of X-Ray Emissions Generated During Laser-Driven Fusion Experiments

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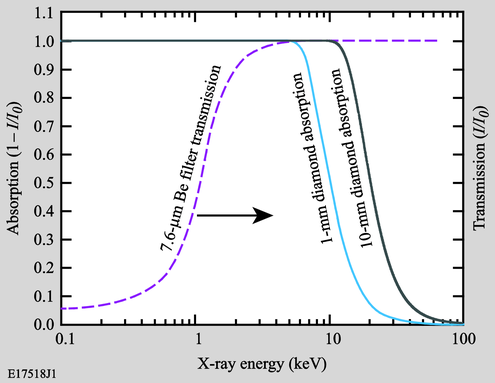
Abstract

We present our measurements of (Cd,Mn)Te photoconductive detectors (PCDs), intended to characterize both the temporal and spectral dependence of x-ray emissions from laser-illuminated targets during inertial confinement fusion experiments. 1-mm-long and 2.3-mm-long $Cd_{0.95}Mn_{0.05}Te$ PCDs with high resistivity ($1.8*10^{10}$ Ω·cm) and adequate mobility-lifetime product (several 10^{-4} cm^2/V) are housed along with a 1-mm-long diamond PCD for direct comparison. The PCDs were preceded by Be filters with 37% x-ray transmission at the 1-keV cutoff energy. The response amplitudes and rise times of our (Cd,Mn)Te PCDs were comparable with the diamond detector's performance, while the decay times were longer (in the 5- to 10-ns range). Using targets of empty plastic shells, we observed two x-ray emission events separated by 1.24 ns: the first event was caused by the hot corona resulting from heating of the target, while the second x-ray emission event resulted from the compressed plastic shell. The 1-mm-long (Cd,Mn)Te crystal response was due entirely to the photoelectric effect in which the spectral absorption exhibited a 1/*e* edge at x-ray energies of 94.2 keV. On the other hand, the absorption edge of the 2.3-mm-long sample was shifted to 126 keV, and our calculation exhibited a non-negligible contribution of the Compton effect.

Motivation



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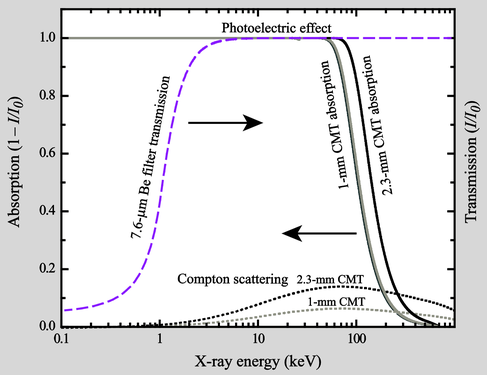
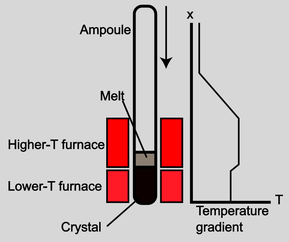
1-mm-long diamond crystal has less than 63% absorption for x rays energy above ~10 keV.

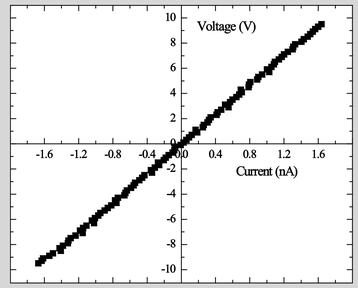
1-mm- and 2.3-mm-long CMT PCDs exhibit similar spectral cutoffs at 94 keV and 126 keV respectively. This will allow the temporal and spectral characterizations of hard x rays currently unobtainable by diamond PCDs.



CdMnTe Sample Fabrication

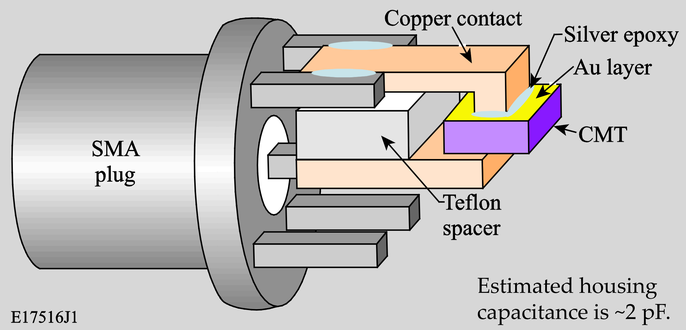


Vertical Bridgeman crystal growth with V-doping = $5*10^{16}$ cm^{-3} and subsequent Cd annealing yields high quality and highly resistive samples.



Resistivity = $1.8*10^{10}$ Ω·cm

Detector Fabrication



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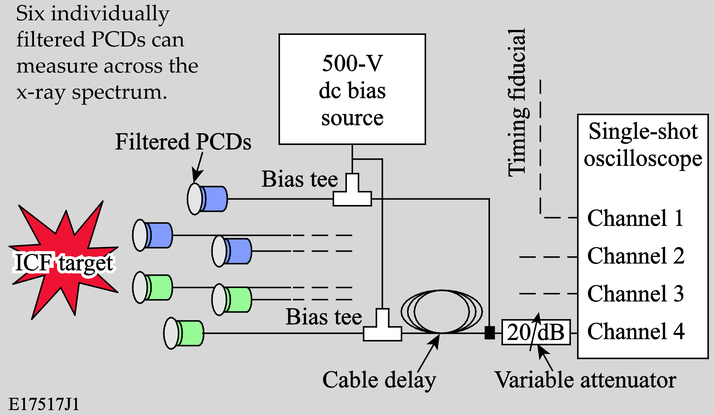
Estimated housing capacitance is ~2 pF.

X-Ray Diagnostics Setup

Six individually filtered PCDs can measure across the x-ray spectrum.



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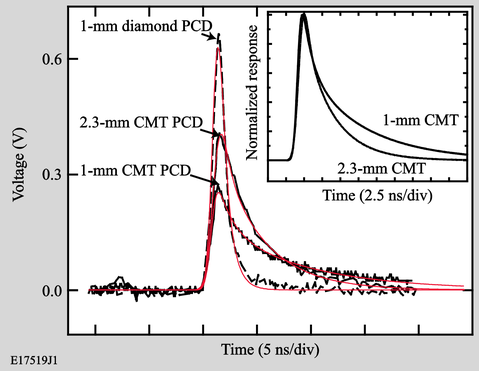
Spherical Target with Stainless Steel Core



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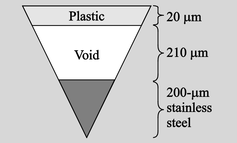
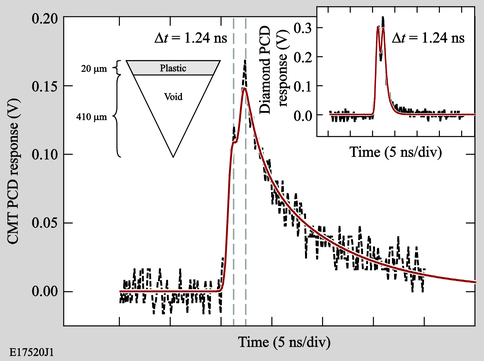
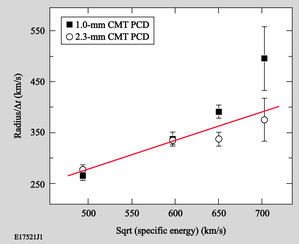


Areas beneath the transients indicate total deposited energy. Our CMT PCDs collected larger quantities of x-rays with energies extending beyond 10-keV.

1-mm-Diamond	τ_{rise} = 1.0 ns	FWHM = 1.3 ns	τ_{slow} = 2.5 ± 0.1 ns	Normalized pulse area = 1.0
1-mm-CMT	τ_{rise} = 1.0 ns	τ_{fast} = 1.6 ± 0.1 ns	τ_{slow} = 10.0 ± 0.5 ns	Normalized pulse area = 1.6
2.3-mm-CMT	τ_{rise} = 1.0 ns	τ_{fast} = 1.8 ± 0.3 ns	τ_{slow} = 5.1 ± 0.5 ns	Normalized pulse area = 1.7

Vacant Spherical Target





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Conclusion

Presented is a demonstration of CMT PCDs as a viable upgrade to the diamond detectors currently used in the x-ray diagnostics of OMEGA laser ICF experiments. Future tests will implement six CMT PCDs with a selection of x-ray filters aimed to characterize the temporal and spectral dynamics of medium-to-hard (20 to 100 keV) x-ray emissions, a task currently beyond the sensitivity of diamond PCDs. The temporal resolution of CMT is presently lower than that of the diamond PCDs; however, modifications to the CMT crystal growth (increasing V doping to 2×10^{17} cm^{-3}) are expected to improve the CMT detector response time.

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