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

Allen S. Cross, James Knauer, and Roman Sobolewski
University of Rochester, Rochester, NY 14627-0231, USA

Y. Cui and R. B. James
Brookhaven National Laboratory, Upton, NY 11973-5000, USA

D. Kochanowska, M. Witkowska-Baran, R. Jakieła, J. Domagała, and A. Mycielski
Polish Academy of Sciences, PL-02668 Warszawa, Poland

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 ($1.8 \times 10^{10}$ 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.

**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 ($1.8 \times 10^{10}$ 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).

**MOTIVATION**

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 = $5 \times 10^{16}$ cm$^{-3}$ and subsequent Cd annealing yields high quality and highly resistive samples.

**DETECTOR FABRICATION**

Silicon epoxy

Estimated housing capacitance is ~2 pF.

**X-RAY DIAGNOSTICS SETUP**

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

**SPHERICAL TARGET WITH STAINLESS STEEL CORE**

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

<table>
<thead>
<tr>
<th>Material</th>
<th>$\tau_{\text{rise}}$ (ns)</th>
<th>FWHM (ns)</th>
<th>$\tau_{\text{slow}}$ (ns)</th>
<th>Normalized pulse area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-mm-Diamond</td>
<td>1.0</td>
<td>1.3</td>
<td>2.5 ± 0.1</td>
<td>1.0</td>
</tr>
<tr>
<td>1-mm-CMT</td>
<td>1.0</td>
<td>1.8 ± 0.1</td>
<td>10.0 ± 0.5</td>
<td>1.6</td>
</tr>
<tr>
<td>2.3-mm-CMT</td>
<td>1.0</td>
<td>8.3</td>
<td>5.1 ± 0.5</td>
<td>1.7</td>
</tr>
</tbody>
</table>

**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 $2 \times 10^{17}$ cm$^{-3}$) are expected to improve the CMT detector response time.