PILATUS4 CdTe Detectors: Enabling Sub-Millisecond Synchrotron-Based *In-situ* Studies under Extreme Conditions

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In-situ experiments in diamond anvil cells and large-volume presses at 4th generation synchrotron-radiation facilities (like MAX IV, Sirius, ESRF-EBS, SLS 2.0) increasingly target fast compression, laser heating, and other dynamic processes, requiring high-energy X-rays (up to 100 keV), large reciprocal-space coverage, and microsecond time resolution to capture transient states in real time [1].

The PILATUS4 CdTe detector addresses these demands. Building on the hybrid photon counting technology of the PILATUS and EIGER families, which have transformed synchrotron-based structural studies over the past two decades [2–5], PILATUS4 CdTe detectors deliver high quantum efficiency at high photon energies (>75% up to 80 keV) allowing for fast data collection through the window material of *in-situ* chambers and diamond anvil cells, and provide a large active area of up to 4M pixels for extensive reciprocal-space coverage. Additionally, their 4 kHz frame rate enables sub-millisecond time resolution with virtually no dead time. Even faster processes can be investigated in pump–probe experiments using the double-gating mode, extending the accessible time scale down to the nanosecond regime [5].

In this contribution, we demonstrate how PILATUS4 CdTe detectors enable advanced structural investigations, showcased by experimental results from MAX IV and ESRF: ultrafast calcination reactions were resolved with 220 µs temporal resolution, and high-speed XRD-CT achieved 32 µm spatial mapping of heterogeneous samples [6]. These results highlight the suitability of the detector for time-resolved PXRD for capturing intermediate phases and scanning 2D/3D phase mapping of heterogeneous samples. A recent DAC study on magma–hydrogen reactions at 13-IDD (APS) [7], performed with a PILATUS3 CdTe detector, illustrates applications that will benefit from the expanded coverage and faster sampling of PILATUS4.

Collectively, these findings demonstrate the potential of PILATUS4 CdTe to advance *in-situ* PXRD, exploiting the capabilities of modern synchrotron sources.

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