The techniques used in nanosecond time-resolved crystallography are described. Future developments are interpreted in terms of a decrease by 0.04 Å in the ionic radius of Ce$^{3+}$ in its 4f$^5$ 5d$^1$ excited state as compared to the 4f$^6$ 5d$^0$ ground state, which causes a contraction of the lattice on the time scale of 1 nsec and a lattice expansion due to heating of the sample to ca. 150 K by the laser pulse. Thermal relaxation of the lattice occurs on a msec time scale.

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The grazing incidence scattering (GIS) technique has been developed for studying the structures of thin amorphous films on substrates with x-ray synchrotron radiation. In this technique, the penetration depth into the sample can be continuously varied from 25 Å to bulk thicknesses by controlling the grazing incident angle of the highly collimated beam. Radial distribution functions (RDF's) from amorphous layers as thin as 250 Å were obtained with a few hours of data collection. Exploiting the energy tunability of synchrotron radiation and anomalous scattering (AS) and EXAFS measurements in this surface sensitive geometry were performed. The method was applied to 2-Ag-GeSe$_2$ films in which the Ag$_n$ was incorporated by photodiffusion. These studies will be presented, as will be investigations of the minimum film thickness which can be synchrotron x-ray pulses and using a gated multichannel analyzer to determine the number of x-rays scattered from individual x-ray pulses. The lattice temperatures and temperature gradients were determined as a function of time following the laser pulses by analyzing time-resolved 111 and 000 Bragg profile measurements in terms of thermal expansion induced strain. The analysis was performed by fitting the measured reflection profiles with dynamical diffraction calculations for one-dimensionally strained crystals. Experimental methods and results, showing surface melting and ~1000°C/micron temperature gradients, will be discussed for both ruby (694 nm) and excimer (248 nm) laser pulses, and the lattice temperature distributions will be compared to detailed heat flow calculations.

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