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Sommario/riassunto	This thesis describes key contributions to the fundamental understanding of materials structure and dynamics from a microscopic perspective. In particular, the thesis reports several advancements in time-domain methodologies using ultrafast pulses from X-ray free-electron lasers (FEL) to probe the interactions between electrons and phonons in photoexcited materials. Using femtosecond time-resolved X-ray diffraction, the author quantifies the coherent atomic motion trajectory upon sudden excitation of carriers in SnSe. This allows the

reconstruction of the nonequilibrium lattice structure and identification of a novel lattice instability towards a higher-symmetry structure not found in equilibrium. This is followed by an investigation of the excited-state phonon dispersion in SnSe using time-resolved X-ray diffuse scattering which enables important insight into how photoexcitation alters the strength of specific bonds leading to the novel lattice instability observed in X-ray diffraction. Finally, by combining ultrafast X-ray diffraction and ARPES, the author performs quantitative measurements of electron-phonon coupling in Bi2Te3 and Bi2Se3. The findings highlight the importance of time-resolved X-ray scattering techniques based on FELs, which reveals the details of interplay between electron orbitals, atomic bonds, and structural instabilities. The microscopic information of electron phonon interaction obtained from these methods can rationalize ways to control materials and to design their functional properties.