# 1 Introduction

For more than a decade laser pump-probe photoelectron spectroscopy has been the primary technique to determine the energy, momentum, and population dynamics of surface states and bulk states in the vicinity of the Fermi level in solids [Bok89, Hai95]. Using synchrotron radiation (SR), which is broadly and continuously tunable, we overcome optical probe-pulse photon-energies, although with limitations on time resolution. SR has been employed, in fact, for a variety of time-resolved spectroscopies spanning the far-IR to the hard-X-ray regimes [Lon94].

The absorption of two synchronized light sources allows us to study the physics of electron dynamics at the surfaces of semiconductors and metals ranging from electron scattering and diffusion to electron-hole recombination, including surface state and defect trapping.
From a fundamental point of view, the detailed mechanisms of electron scattering, capture and recombination at surfaces are of great interest. Further motivation to understand electron dynamics stems from the fact that interfaces and surfaces are of technological relevance since all solid-state devices from photovoltaics to transitors require coupling of electrons to and from the outside world.
Implicit in the effort to study electron dynamics at surfaces is the ability to time-resolve the ultrafast scattering processes which result in energy and momentum relaxation, recombination and diffusion. Moreover, pump-probe photoelectron spectroscopy is the primary technique to determine the energy, momentum, and population dynamics of excited surface and bulk states in solids. Using synchrotron radiation (SR) combined with lasers in photoemission opens a broad and continuously tunable range of occupied as well as normally empty states and allows us to study their dynamical behavior. However, the time resolution is limited by the pulse duration of the synchrotron bunch to typically 10 to 30 ps.

In addition repetition rates of lasers are lower than synchrotron repetition rates preventing excellent signal averaging. Nevertheless, synchrotron technology continues to make significant advances in the reduction of photon pulse-width and together with new improvements in laser technology, e.g, shorter pulse widths and higher intensities at higher repetition rates, the study of electron dynamics will proceed.

The present thesis describes three experiments, in chronologically order. They demonstrated the potential of time-resolved photoelectron spectroscopy at higher

photon energies. In Chapter 2 gives an introduction on the experiment and on the synchronization scheme between laser and synchrotron pulses.

Chapter 3 summarizes our first attempts where we tried to optically induce a phase transition in vanadium dioxide films. The goal of this experiment was not achieved since heat accumulation produced a static phase transition.
The second and most successful experiment is outlined in Chapter 4. We studied laser-induced electronic changes in the valence band and silicon 2p core-level of the clean Si(100)c(4×2) surface. The fundamental time scale for many of the observed dynamical processes is picoseconds.

The final experiment is a study of picosecond spin dynamics in gadolinium films resolved by linear dichroism in photoemission of the 4f shell. We demonstrate that upon optical excitation of the electrons in the valence band the magnetization of the gadolinium film is reduced.