The developments of short and intense laser pulses have motivated many studies in laser-solid interactions including metals, semi-conductors, and dielectrics. In the case of large band gap dielectric materials, the interaction with an intense laser pulse is a complex phenomenon which may be described as follows. First, the valence electrons are promoted to the conduction band through photon absorptions. These conduction electrons can then further absorb the laser energy to be driven to higher energy levels. Because of the relation between ionization and absorption, instantaneous changes in the rate of production of conduction electrons may in turn affect the propagation dynamics of the laser pulse. The electrons also undergo collisions with various particles such as phonons or other electrons, leading to their relaxation and the heating of the lattice on longer timescales. The energy absorption of the laser pulse by the material, which the control is crucial for many experiments and applications, is thus directly related to both the electron dynamics and pulse propagation.

The first part of the talk will be devoted to the modeling of the coupling between ionization and pulse propagation in dielectric materials. A time-dependent ionization model coupled to 3D Maxwell’s equations will be presented. The interaction between both ionization and propagation dynamics will be demonstrated for two cases of practical interest: frequency conversion and propagation of chirped pulses. This coupling for the case of a dielectric nanoparticle will then be addressed, exhibiting the influence of the local laser electric field enhancement on the electron production.

The second part of the talk will address the full electron dynamics, including the various processes in the conduction band. In the case of a dielectric material, the energy distribution of the conduction electrons is obtained by solving a kinetic equation including all the main processes for energy exchanges (photon absorption, electron and phonon collisions). A comparison of the theoretical predictions to photo-emission experimental observations allows us to conclude on the reliability of the theoretical developments and to deeply understand the main physical processes driving the electron dynamics. Results for a metallic target, including modeling and photo-emission experimental results, will be also presented.