The process of photosynthesis begins with a capture of sunlight and its quick conversion into the chemical energy. Both these primary processes take place in a specially designed photosynthetic apparatus that is present in cells of all photosynthetic organisms. In green sulfur bacteria the apparatus consists of a massive light-harvesting antenna (chlorosome), intermediate antennas (baseplate complex and FMO proteins) and of the reaction center, where the conversion into the chemical energy occurs. The energy flow through the apparatus can be monitored by time-resolved spectroscopy techniques. Coherent two-dimensional electronic spectroscopy (2DES) in one of such techniques, which combines high temporal and spectral resolution, and therefore it is especially well suited for studying multichromophoric systems such as photosynthetic apparatus. This thesis describes the principles of the 2DES technique and outlines the basic facts about the photosynthetic apparatus of green sulfur bacterium Chlorobaculum tepidum. Finally, it summarizes the investigation of the photosynthetic machinery using 2DES. Results presented in this thesis provide new insights into the exciton diffusion and vibrational coherences within chlorosomes, excitonic structure of the baseplate and the overall energy flow through the entire photosynthetic apparatus in whole cells.