This compilation includes six chapters that present various advancements in materials science research. Chapter One suggests new rigorous approaches to the mathematical modeling and electromagnetic analysis of 2D photonic crystals. Chapter Two details the results of a dynamical study of positron channeling in a (11, 9) chiral single-wall carbon nanotube. Chapter Three uses a deconvolution of IR spectra to attribute the spectra components to definite phases in multiphase proton exchange waveguides. Chapter Four describes the third-order nonlinear optical application of organometallic compounds. Chapter Five focuses on evaluating the behavior of cementitious composites produced with different concentrations of multi-walled carbon nanotubes providing a relationship between mechanical properties, ultrasound pulse velocity and the frequency resonance method. Finally, Chapter Six deals with the design of a capillary electrophoresis sensor based on micro-structured fibers.