Silicon as a promising anode material can enhance the capacity of Li-ion battery significantly. However, the huge volumetric strain (up to 270%) caused by Li insertion and extraction will induce high internal stress and cause fracture and pulverization of Si electrode. This will degrade its performance and limit its broader utilization. Recent experimental observation shows that a clear phase boundary between the pristine Si and resultant Li-Si alloy could be seen in the first lithiation half cycle of both crystalline and amorphous silicon. Based on this observation, a phase-field model with anisotropic reaction kinetics is developed to seek an alternative way of simulating the phase evolution and coupled large deformation during the lithiation of silicon electrode. This model only hypothesizes linear kinetics, and does not need to introduce kinetic-dependent plasticity or modify basic thermodynamic quantities. A set of coupled phase-field and mechanics equations are solved by finite element method to study the evolution of Li concentration profile and deformation. By considering the role of stress in lithiation process, this model is used to explain the self-limiting lithiation of Si electrodes. In addition, the stress state as a result of the inhomogeneous deformation is used to explain the surface cracking and determine a critical size of Si nano-particle to avert fracture. We also simulated the morphology evolution of a Si disk during lithiation.