In this work, the single crystal Chemical Vapor Deposition (CVD) diamond detectors were designed and fabricated to investigate and detect any possible charged particle and neutron emissions from gas-phase Low Energy Nuclear Reaction (LENR) experiments at room temperature. The diamond detectors were used in two experimental gas loading systems, palladium-deuterium, and nickel-hydrogen. Palladium and nickel were used as host materials. Thin film layers of Ti/Pd and Ti/Pt/Au/Ni were deposited on the CVD diamond plates by evaporation techniques to create an Ohmic contact. Electronic characterizations of the detectors were completed by current-voltage measurements and energy calibration with alpha particles. The simulation and experimental run of the diamond detector with alpha and beta radiations exposures were done to determine the response of the detector to charged particles. The experimental results show that the diamond detectors observed and detected significant signal bursts from the gas loading experiments. The results from this work demonstrate that diamond detectors are suitable for alpha and beta radiation detection.