Semiconductor surface clean is sometimes perceived as costly but long recognized as pivotal in determining the final semiconductor device performance and yield. In this dissertation, I investigated the effectiveness of crystalline silicon surface cleaning by a simple UV-ozone process in comparison to the industry standard RCA clean for silicon photovoltaic applications. A unique method of processing the silicon surface effectively by UV-ozone cleaning has been presented. Despite being simple, UV-ozone cleaning results in a superior surface passivation quality that is comparable to high-quality RCA clean. When used as a stack dielectric-UV-ozone oxide overlaid by aluminum oxide—the thickness of UV-ozone oxide plays an important role in determining the passivation quality. UV-ozone treatment results in an outstanding passivation quality, achieving the effective carrier lifetime of 3 ms and saturation current density of 5 fA/cm². In addition, I present a simple and effective technique to extract values of electron/hole capture cross-section for the purpose of analyzing the interface passivation quality from already measured surface recombination parameters of saturation current density, interfacial trap density and total fixed charge, instead of measuring on the separately prepared metal-insulated-semiconductor (MIS) samples by the techniques: frequency-dependent parallel conductance or deep-level transient spectroscopy.