In our previous work, we demonstrated that minority carrier lifetime can be improved after an atmospheric pressure plasma treatment on amorphous silicon suboxide passivated silicon surface [1]. In this work, we explore the feasibility to deposit silicon oxide passivation thin films using a fully atmospheric pressure plasma coater to replace vacuum based processes such as PECVD. The experiment was carried out using a Plasma Plus System (Plasmatreat, Germany). Silicon wafers that underwent a standard cleaning procedure were dipped in hydrofluoric (HF) acid for chemical oxide removal. An evaporator that can operate at different temperatures was used to vaporize the liquid precursor hexamethyldisiloxane (HMDSO) before it was charged into the plasma jet using nitrogen (N2) as a carrier gas. The plasma species after glow-discharge were dispensed onto the wafer surface to form the passivation film. The film properties were adjusted using various deposition parameters: HMDSO flow rate, evaporator temperature, distance between plasma nozzle head and the surface, and the speed of the nozzle head travelling across the wafer. The thickness of the film was determined by both spectroscopic ellipsometry and transmission electron microscope, while the passivation quality was measured using quasi-steady-state photoconductance decay method. It was found that using the atmospheric pressure plasma coater, symmetrical passivation can be realized in less than 50 s with good uniformity. The lowest controllable oxide thickness was around 5 nm, which represents a promising application in heterojunction solar cell fabrication. By using device relevant oxide thickness, good minority carrier lifetime can be achieved. Comparing with passivation samples prepared by vacuum process, the atmospheric pressure plasma coater can achieve similar level of passivation with better uniformity in a shorter time and a much lower cost. However, it was discovered that the resulting oxide properties are highly sensitive to the abovementioned parameters. In particular, the evaporator temperature determines the carbon content in the film, which in turn affects the passivation quality and surface contaminant concentration. The precursor flow rate, together with the nozzle head travelling speed determines the growth rate and the film density. Currently, good passivation quality at device relevant thickness can only be achieved on a fairly small process window.

![Figure 1. Schematic of the Plasma Plus process.](image)

References