Silicon Nitride Films for Photovoltaic Application Deposited in an Industrial PECVD

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Silicon nitride (SiN) film deposited by a plasma-enhanced chemical vapour deposition (PECVD) is widely used in photovoltaic industry as an anti-reflection coating (ARC) [1] and emitter passivity [2] [3]. As a third advantage, the large amount of hydrogen resulting from plasma gases dissociation and incorporated in the SiN film can be driven into the solar cell during deposition and the contact firing step, leading to excellent bulk passivity for multi-crystalline silicon solar cells. For an efficient ARC, the SiN layer is designed for an optimum wavelength of 580 to 680 nm corresponding to a layer thickness between 70 and 80 nm and a refractive index n around 2.0 [4].

In this work, we intend to determine the deposition parameters leading to optimal optical characteristics of SiN film for photovoltaic application and then evaluate its effect on electrical parameters of solar cells. The deposition was performed in an industrial direct PECVD using a gas mixture of SiH$_4$ and NH$_3$. The study was carried out on 4 inches H.E.M. multi-crystalline wafers.

The refractive index was obtained for the ratio of process gases R= NH$_3$/SiH$_4$ between 5 and 9. Gas flow rates have been chosen to have a better film thickness uniformity.

An optimal thickness around 75 nm and refractive index between 1.91 and 1.98 were obtained for a 3.5 kW power and temperature of 380°C resulting on batch uniformity of, respectively, 3.5% and 1.8%.

In the wavelengths range of 400-1100 nm, the AM1.5 weighted reflection has been reduced to 10%.

Removal of the SiN film by low power barrel plasma etching allows the evaluation of the emitter passivity and ARC effects. As regard to the first one, a relative diminution of 3% to 7% for open circuit voltage and important increase of saturation current were observed. For the second effect, $I_{sc}$ is reduced by 20%. In other words, the nitrure layer improves the cell efficiency of more than 1% absolute [4].

References