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EFFECTS OF LASER LINE WIDTH AND SCRIBING DIRECTIONS ON PERFORMANCE OF TRANSLUCENT SILICON THIN-FILM BUILDING-INTEGRATED PHOTOVOLTAIC MODULES

Abstract:

Recently, building-integrated photovoltaic (BIPV) modules have attracted great attention since they can not only be a part of building materials but also generate electric power. Among many types of BIPV modules, translucent hydrogenated amorphous silicon (a-Si:H) solar module has expand the range of applications to include windows, sunroofs and skylights, where it can be useful for both purpose of generating electricity and transparency for sunlight at the day time. There are two main types of translucent a-Si PV modules. The first one builds with a transparent conductive oxide thin film, instead of the metal film, as the back electrode. However, this type of module only allows light with wavelengths longer than 500 nm to pass through, leading to a reddish light and therefore visual discomfort. The other type translucent a-Si PV module uses the so-called “P4 laser process” to remove silicon and back electrode layers so as to allow nature light transmission. In this study, 10% transmittance a-Si:H thin film solar modules are fabricated by laser processes. Effects of P4 laser line width and scribing directions, vertical, spot-like and horizontal in relation to the modules, are investigated. Firstly for the P4 laser line width optimization from 30-60 μm, the experimental result shows that with a constant transmittance, a module having a large line width could improve fill factor and conversion efficiency due to reduction of scribed line number needed, thus decreasing the damage of silicon layers. The 60 μm P4 laser line width leads to a minimum of performance degradation of about 11%. Further increasing the line width may need to introduce additional optical lens system to change laser beam distribution. Secondly, I-V curves and parameters of the modules fabricated using three different scribing directions show that the vertically scribed module has a high series resistance of 19.3 Ω due to the long carrier transport length and small cross-sectional area. The spot-like module has the highest leakage current and diode ideality factor, indicating a reduced silicon film quality. This is likely due to spot-like scribing creating the largest amount of laser line edges, which usually contains high defects caused by laser thermal affection. The horizontally scribed module has the best fill factor, and the intermediate open-circuit voltage and short-circuit current. Finally, the horizontal scribing can lead to the lowest conversion efficiency degradation of about 12.7%. This paper can be helpful for applications of BIPVs.

Keywords:

building-integrated photovoltaic, translucent, amorphous silicon module

JEL Classification: Q40, Q20