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High-throughput front and rear side metallization of silicon solar cells using rotary screen printing

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Abstract

Rotational screen printing (RSP) has recently attracted attention as a highly promising high-throughput alternative for the metallization of Silicon solar cells. Compared to other metallization approaches, RSP is already a well-developed printing method which has been used for various industrial applications during the last decades. The unique benefit of this technology is the ability to apply a thick film metallization combined with a high throughput. Within the present work, we will discuss the actual achievements and challenges of this approach. We show the results of Aluminium back surface solar cells with a RSP rear side metallization and a mean conversion efficiency of η = 19.4 % compared to reference solar cells with flatbed screen printed rear side metallization and a conversion efficiency of η = 19.3 %. We further investigate the properties of fine line cylinder screens used for RSP and conventional flatbed screen printing. Using RSP with a fine line cylinder screen, we printed contact fingers with a mean width down w_f = 61 µm. Finally, we discuss the path to a further optimization of this highly promising approach.

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Keywords: Silicon Solar Cells; Metallization; Rotational Printing; Rotary Screen Printing

1. Introduction

Today, flatbed screen printing (FSP) is the state-of-the-art technology for solar cell metallization. However, the throughput of a single FSP metallization line is currently limited to approx. 2000 wafers/h [1]. A highly promising route to considerably increase throughput is the usage of rotational printing methods. Such methods can realize an

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expected throughput of at least 6000 wafers/h on a single metallization line. However, new metallization approaches can only compete with flatbed screen printing technology under certain preconditions: they have to be fast, reliable, easy-to-handle and must avoid a cost-intensive development of new consumables. Rotary screen printing (RSP) is a well-established and highly developed printing technology [2,3] which is able to combine these benefits.

To date, this technology is primarily used on web-based materials (i.e. label or textile printing [7]) with a printing speed of up to 100 m/min. Similar to flatbed screen printing, a woven screen mesh covered with a partly open emulsion layer is used as printing form. However, in contrary to the flat screen used in FSP, cylinder-shaped screens are used for RSP. The meshes of such screens consist of up to 400 wires per inch (mesh count). Due to stability reasons of the cylinder screen, the wires of the mesh are significantly thicker compared to flat screens (Fig. 1). FSP requires two printing sequences. Firstly, the open areas of the screen are filled using a metal flood bar. Secondly, the paste is pressed through the openings of the flat screen using a flexible squeegee. Within the RSP process, the paste is constantly pressed through the screen openings by a fixed squeegee within the rotating screen cylinder (Fig. 2). A pre-filling of the screen is thus not necessary. RSP requires a lower paste viscosity compared to FSP pastes to ensure a good paste transfer through the screen openings [3]. The ability to transfer thick film metallization patterns makes RSP interesting for both – front and rear side metallization of c-Si solar cells.

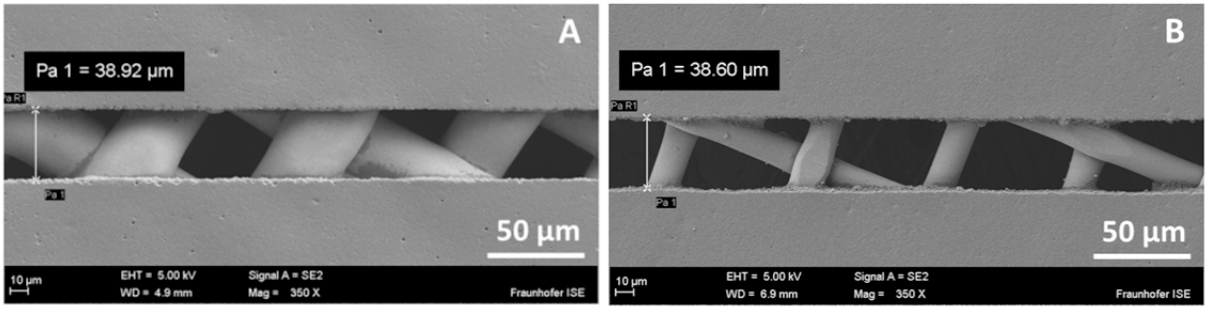

Fig. 1. SEM image of a fine line contact finger opening within a rotary screen (A) and a flatbed screen (B). The significantly greater thread thickness of the rotary screen mesh (d_{RSP} = 28 µm) compared to the flatbed screen mesh (d_{FSP} = 18 µm) is clearly visible.

First attempts to use this technology for solar cell metallization date back to the year 1999, however no results are known from these activities [4]. Results of a first pre-test have been published recently [3]. Within this work, we provide a detailed investigation of the paste rheology and the metallization results of RSP on the front side in comparison to reference cells using flatbed screen printing. The results can be regarded as a starting point for the further development of this highly interesting metallization approach.

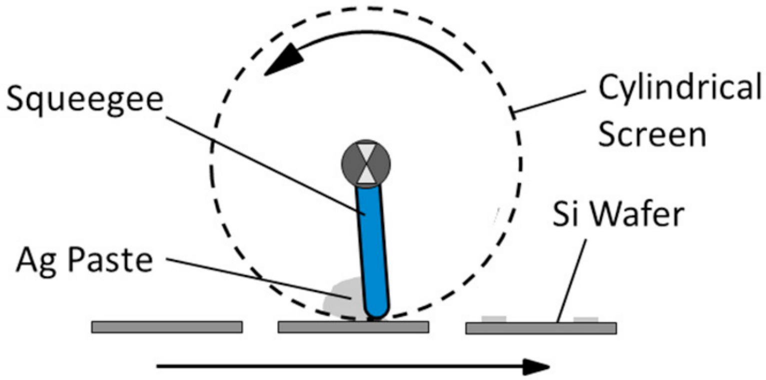

Fig. 2. Schematic view of a rotary screen printing unit for solar cell metallization