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Advanced alkaline texturing and cleaning for PERC and SHJ solar cells

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Abstract

The seventh edition of the ITRPV specifies a throughput for new wet benches of 7200 wph, with an increase up to 10000 wph until 2026. In this work, an advanced process sequence for high throughput alkaline texturing is described that allows tool manufacturers to reach the ITRPV scenario. This sequence furthermore enables increased batch sizes and integration into existing production lines. Using a new wetting agent, the texturing time was reduced from 12 to 6 minutes. Moreover the texturing bath's lifetime was extended up to 1000 runs, while simulated chemical and waste concentrations within the process baths even suggest the possibility of a continuous process. Further improvements could be achieved with respect to water and chemical consumption, as well as the avoidance of organically loaded waste. The described process sequence is built from a modular system and can be easily adapted to different cell concepts. The main steps are described and can be optimized regarding quality and operational costs. For a state-of-the-art PERC system, the uniformity of the alkaline texturing process during a 35-day period on a full production line is reported. To increase the viability of SHJ cells for mass production, the decrease of complexity and costs per wafer is a key step for tool manufacturers. Hence, we present first results from a shortened lab scale production process.

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Keywords: alkaline texturing; wet chemical processes; additive; PERC; silicon heterojunction;

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Nomenclature

Al-BSF	aluminium back surface field
CWD	cold water dryer
HWD	hot water dryer
IPA	isopropyl alcohol
PERC	passivated emitter and rear cell
PERT	passivated emitter rear totally diffused
PL	photoluminescence
pSC1	pseudo standard clean
QSSPC	quasi-steady-state photoconductance
RCA	Radio Corporation of America (clean)
SC1	standard clean 1
SC2	standard clean 2
SDR	saw damage removal
SHJ	silicon heterojunction
TMAH	tetramethylammonium hydroxide
WAD	warm air dryer
wph	Wafers per hour

1. Introduction

With the successful introduction of diamond wire-based sawing for monocrystalline silicon wafers and the steady rise in wafer output, the downstream processes have to follow. In its seventh edition (October 2016) the International Technology Roadmap for Photovoltaic (ITRPV) predicts a steady increase of throughput for wet chemical process tools for solar cell applications [1]. The prediction of a necessary output of up to 10000 wafers/h (gross) for the wet chemical steps until 2026 will be challenging for all tool manufacturers. The switch to more challenging cell concepts based on n-type material, like heterojunction cells with their increased demand on the surface properties, further applies pressure to cell manufacturers.

With PERC cell lines presently being the favoured concept for the expansion of cell manufacturers worldwide, the option to introduce SHJ cell lines is strongly hindered by the operational costs and the invest. Especially the running costs can be significantly reduced for existing PERC cell lines, as the results from large-scale production demonstrate saving potentials on chemicals and water consumption. Currently, the average stabilized efficiency advantage of SHJ cells in comparison to state-of-the-art PERC cells is about one percent absolute for monocrystalline material [1]. Hence, the assessment of the most compact process to fulfil the requirements for SHJ cells is a necessity to guarantee the benefit for the cell manufacturer over widely used cell concepts.

2. Wet chemical processes in batch tools

The three main objectives for most wet chemical tools for processing of monocrystalline wafers have been quite stable in the last decades. Usually, it can be distinguished between removal of the saw damage, reduction of reflectivity by means of anisotropic etching to create a pyramidal surface and conditioning of the new surface via extensive cleaning procedures for the following steps [2]. To achieve these aims, most tools focus on three different groups of process steps and integrate different baths as needed. The as-cut wafers are commonly treated with a pre-clean step to get rid of organic residues and to even out the wafer surface. Afterwards, the characteristic surface structure is anisotropically etched using alkaline chemicals like KOH, NaOH or TMAH and an organic additive. A few years ago, when IPA was still used, this step was limiting the throughput of batch tools, however, with the development of fast etching processes, the cleaning and drying steps gained more attention. The final step is the post-clean and within this group all processes regarding the removal of the organic additive, removal of metal ions, formation of an oxide or hydrogen terminated surface and drying are pooled. Figure 1 shows a schematic overview of commonly applied process steps for the mass production of PERC cells, either for IPA- or additive-based PERC cells. The column denoted as SHJ will be discussed later in this work.

Starting from the cleaning procedures of the semiconductor industry, the RCA clean established by Werner Kern was a stable process chain for silicon wafers for photovoltaic applications [3]. For the removal of persistent organic contaminations, the preliminary treatment with a sulfuric-peroxide mixture (SPM) was advised. This bath is composed of a highly concentrated mixture of sulfuric acid with hydrogen peroxide. This routine combined two steps called SC-1 and SC-2, with the first one being a heated alkaline mixture of hydrogen peroxide and ammonium hydroxide and the second one being a mixture of hydrochloric acid and hydrogen peroxide at elevated temperatures. The SC-1