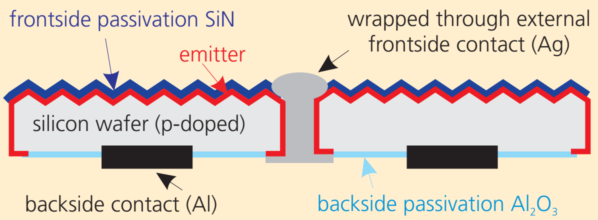
BACKSIDE PASSIVATION OF CRYSTALLINE SILICON SOLAR CELLS

THE TASK

The BMBF funds the project "Saxony Photovoltaics Automation Cluster" S-PAC (id 03WKBW03C). A task in this project is the development of flexible and compact automated modules for the fabrication of metal wrap through solar cells (MWT solar cells). In MWT cells the external frontside contact is moved to the backside of the cell (Fig. 1). The advantage is reduced shading losses on the front side and thus an improved efficiency of the solar cell. As part of the S-PAC project we attempt to combine this concept with a backside passivation of the solar cell.

Schematic representation of a MWT solar cell



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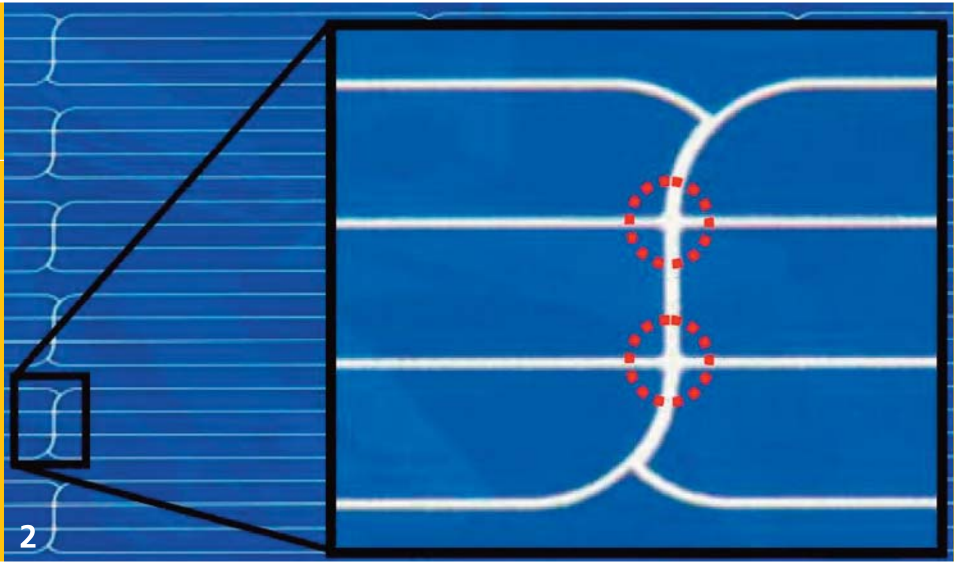
Fraunhofer IWS engineers have developed an atmospheric pressure process to deposit AlO_x passivation layers. The module can be integrated into a laser machine for processing MWT cells. To make this work the high throughput potential of the system requires matching high deposition rates for the passivation layer. Additional requirements address the use of easy to handle precursors and low concentrations of environmentally damaging and toxic waste gases.

OUR SOLUTION

The selected deposition method was ultrasonic spray pyrolysis. This process works at atmospheric pressure and can be integrated as an inline process. The precursors are stable aqueous or organic aluminum solutions. These are sprayed through an ultrasonic nozzle onto the preheated wafer. A first step was the evaluation of the precursor chemistry by wet chemical deposition with spin coating.

The precursors were aluminum triisopropoxide and aluminum sec-butoxide. Aluminum triisopropoxide is a solid powder that was dispersed in water. Adding a drop of nitric acid created a stable sol. The sol particle size (X_{DLS} value) was 17 nm. The fabrication of the sol based on aluminum sec-butoxide was performed using ethyl acetoacetate and isopropanol. Both were spun onto boron-doped 4" silicon wafers (1 - 5 Ω·cm, thickness 525 µm ± 20 µm, frontside polished). Subsequently the wafers were heated at atmospheric pressure. Varied parameters included the synthesis conditions of the sols, the wafer pretreatments, the coating thickness and the heat treatment regime.

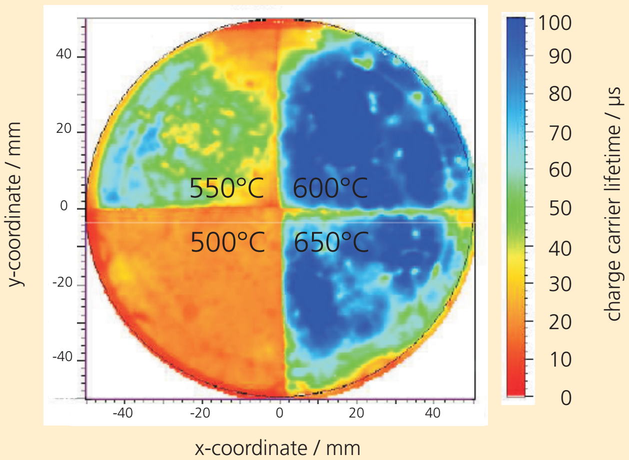


RESULTS

The thickness of the studied coatings was 33 nm – 45 nm. After heat treatment the coatings have a stoichiometry nearly identical to Al_2O_3. Aluminum oxide films made from a sol based on an aqueous solution of aluminum triisopropoxide had an EDX measured Al/O ratio of 58.5/41.5 at-%. The organic sol from aluminum sec-butoxide yielded a ratio of 60.4 /39.6 at-%.

XPS was applied to search for carbon and nitrogen contaminations in the coatings. None were found up to a sputtering depth of 10 nm. FTIR transmission spectroscopy was performed to detect organic groups in the coatings after heat treatment, which may originate from the sols. No traces were found. At a wavelength of 630 nm the measured refractive index was in the range from 1.52-1.55. The average roughness of the coatings (R_a) was 2 nm (aluminum triisopropoxide sol) and 0.5 nm (aluminum sec-butoxide sol).

Mapping of the charge carrier lifetime of differently heat treated microelectronic wafers with AlO_x passivation layer based on aluminum triisopropoxide sol



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Charge carrier lifetimes (CCLT) were determined using microwave detected photoconductivity. The coatings made from the aluminum triisopropoxide sol achieved up to 97 µs. We found that the CCLTs depended significantly on the selected heat treatment. The best CCLT was reached at a heat treatment temperature from 600 °C to 650 °C (Fig. 3).

In the future these coatings will be deposited on 156 mm x 156 mm and 180 µm thin solar wafers. Research will focus on increasing charge carrier lifetimes and on the influence of the deposition process on the laser produced vias.

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