Water Vapor Passivation (VVVP) vs. Plasma Passivation Procedures

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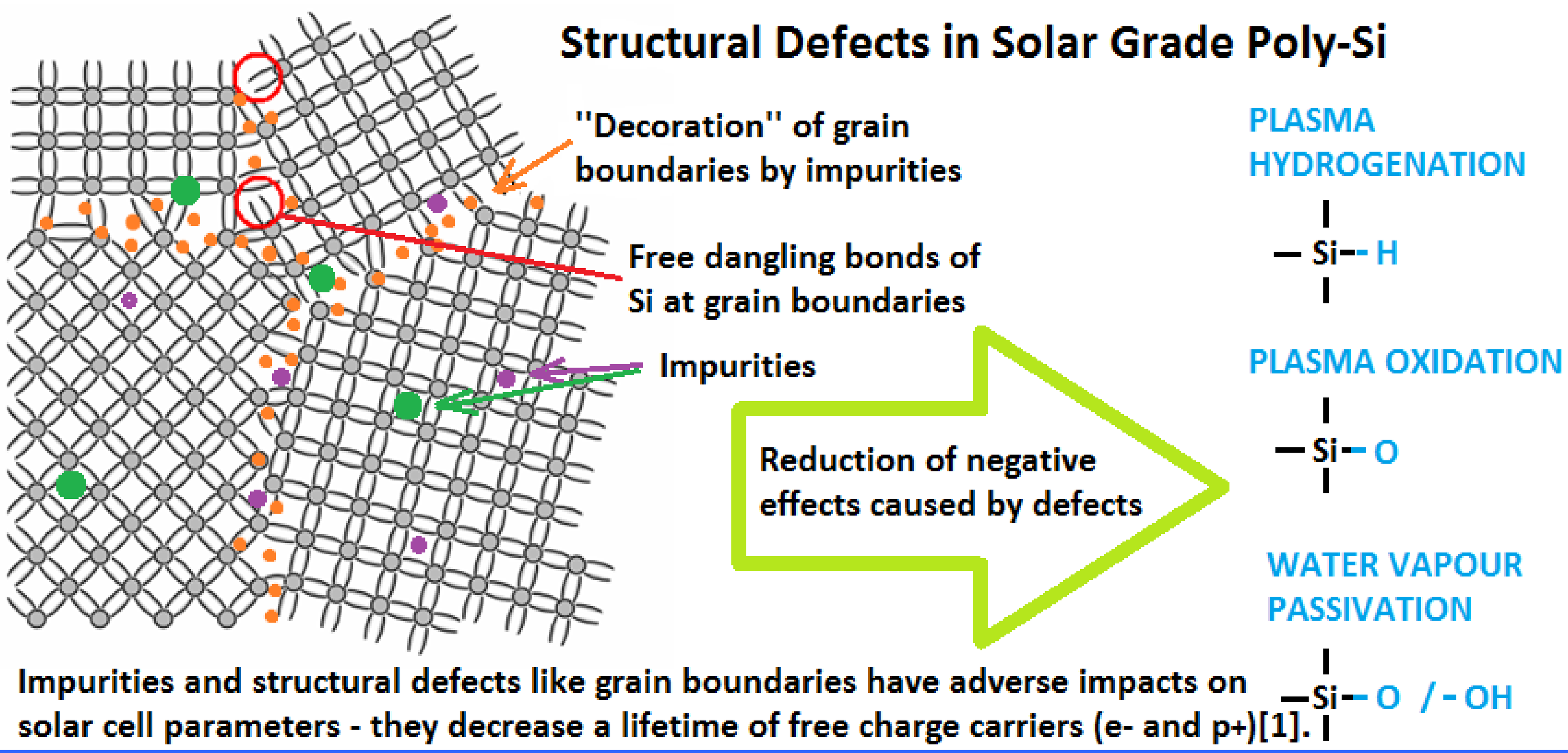
ABSTRACT

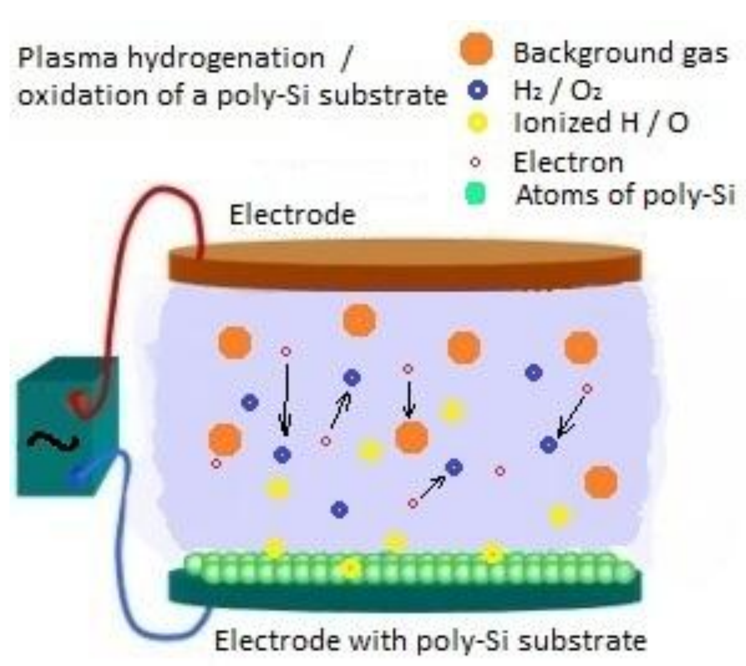
Short comparison of plasma hydrogenation and oxidation with water vapor passivation is proposed. Plasma treatments are powerful tools for improvement of solar cell parameters. Nevertheless, cheaper and more effective approaches have to be searched for the thin film solar cells to be competitive. Water vapor passivation is a new alternative which would satisfy requirements of low purchase and operation costs.

INTRODUCTION



TRADITIONAL PASSIVATION TECHNOLOGIES

HYDROGEN AND OXYGEN PLASMA TREATMENTS



During these procedures, atomic H / O is bonding to dangling bonds of silicon at grain boundaries, reduce its activity and also activity of other defects. They are suitable for, e.g. thin film transistors (TFTs) and solar grade silicon. Oxygen plasma treatment is also suitable for improvement of poly-Si/SiO_x interface in TFTs.
Temperature: 200°C – 350°C, pressure: 0.016 Pa – 200 Pa, power: 150 W – 900 W, duration: 10 s – 6 h [2, 3, 4].

Fig. 1.: Hydrogen / oxygen plasma passivation.

Reduction of defect density, decrease of potential energy height at grain boundaries → increase of Hall mobility and electrical conductivity. Well-known technique, already implemented to manufacture, passivation of bulk materials.

Introduction of a high amount of hydrogen which forms H_2 in a silicon lattice → a tensile stress. Equipment – expensive vacuum system, H_2 or O_2, high voltage, heating of a sample, etc.

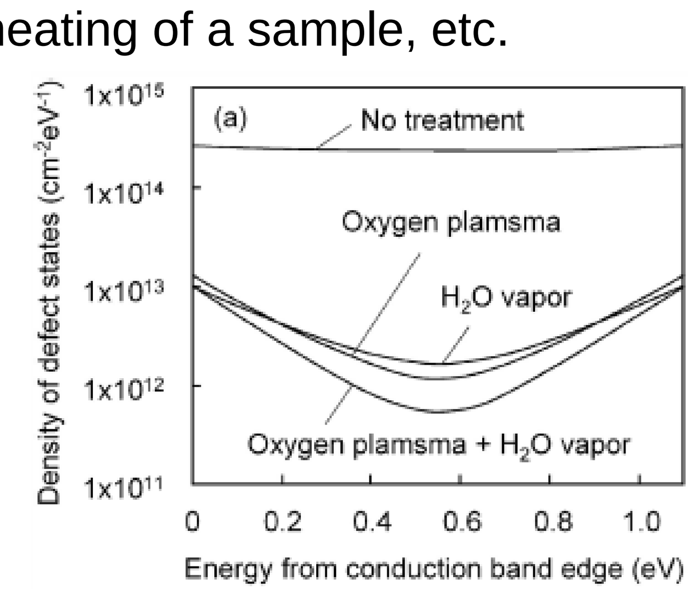


Fig. 2.: Density of acceptor-type states of undoped poly-Si film with the thickness 25 nm [5].

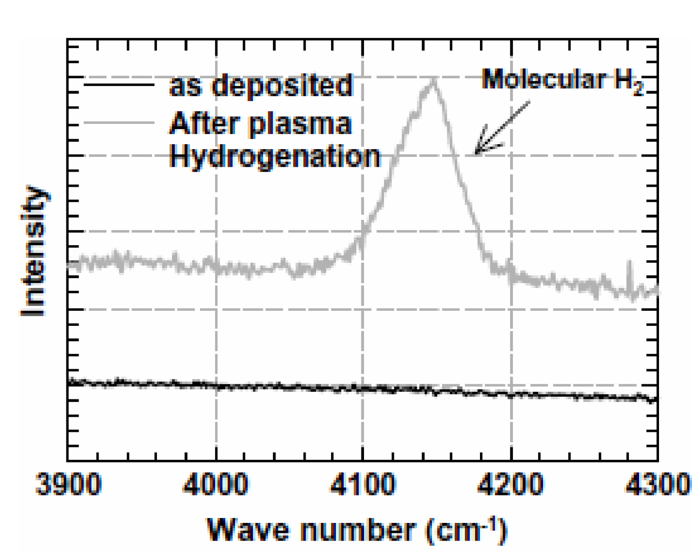


Fig. 3.: Hydrogen molecules peak defect before and after hydrogenation [6].

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WATER VAPOR PASSIVATION – NEW APPROACH

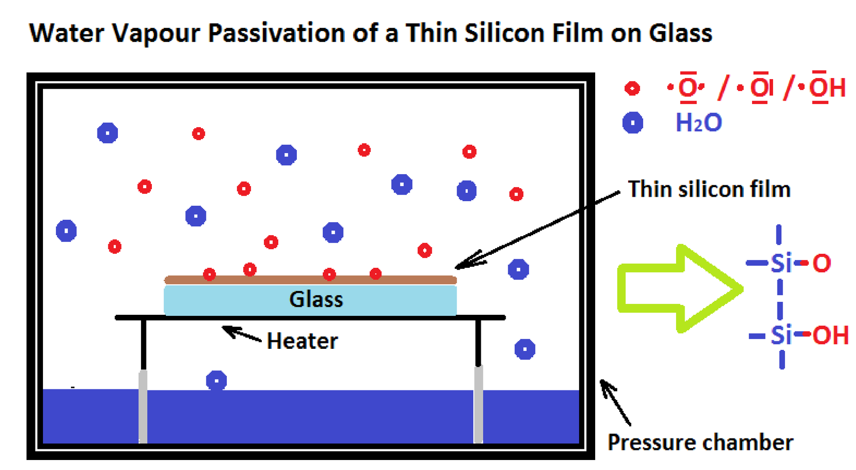


Fig. 4.: Steamer with a thin silicon film on glass during a passivation.
Temperature: 270° C – 350° C, pressure: 10^5 Pa – 13 x 10^5 Pa, duration: 1 h – 3 h [7, 8, 9].

WVP – no special gas or vacuum system is needed.

WHY WVP? → **To decrease manufacturing costs → to be competitive.**

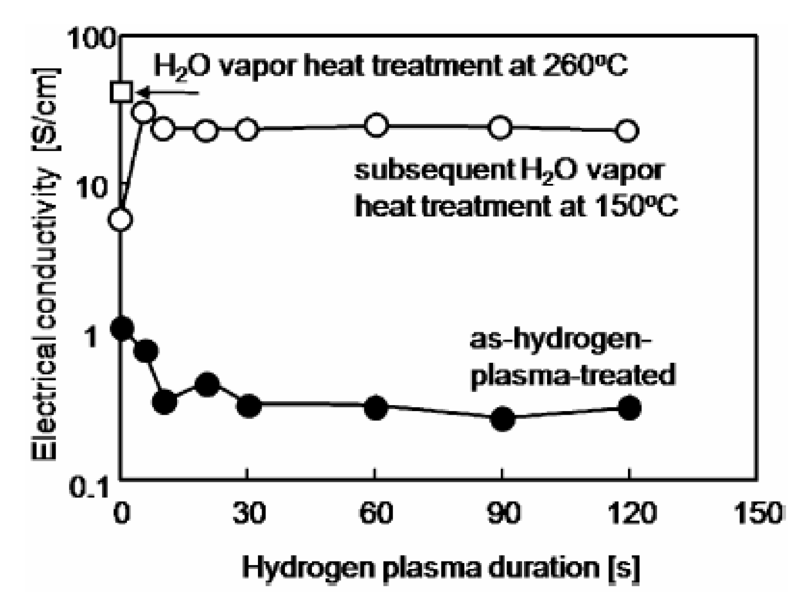
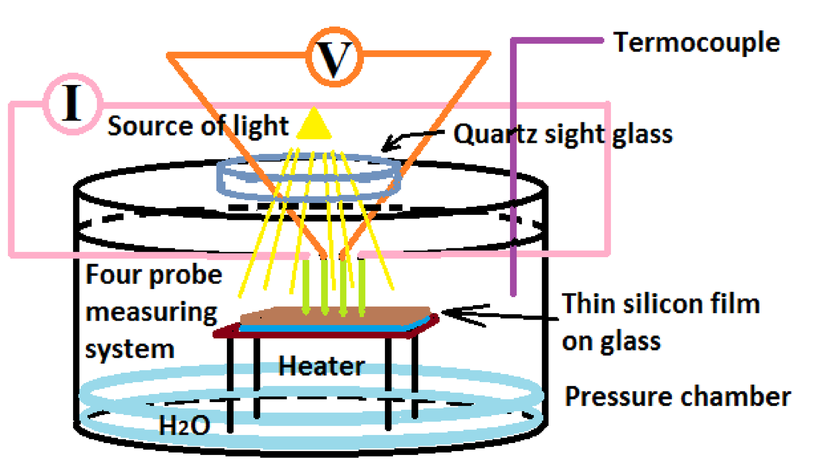
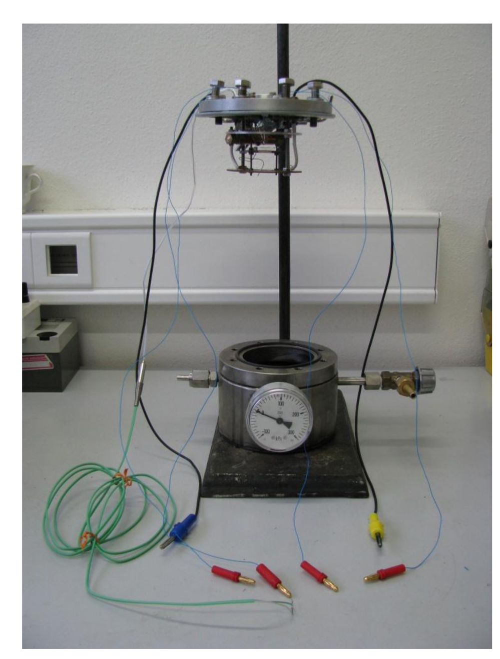


Fig. 5.: Electrical conductivity of 2 x 10^{19} cm^3 phosphorus-doped silicon films as a function of duration of hydrogen plasma treatment at room temperature for samples as-hydrogen-plasma-treated and with subsequent 4.7 x 10^5 Pa H_2O vapor passivation at 150° C for 6 h. The electrical conductivity was also presented for the case of heat treatment with 1.3 x 10^6 Pa H_2O vapor at 260° C for 3 h alone [10].

MY RESEARCH





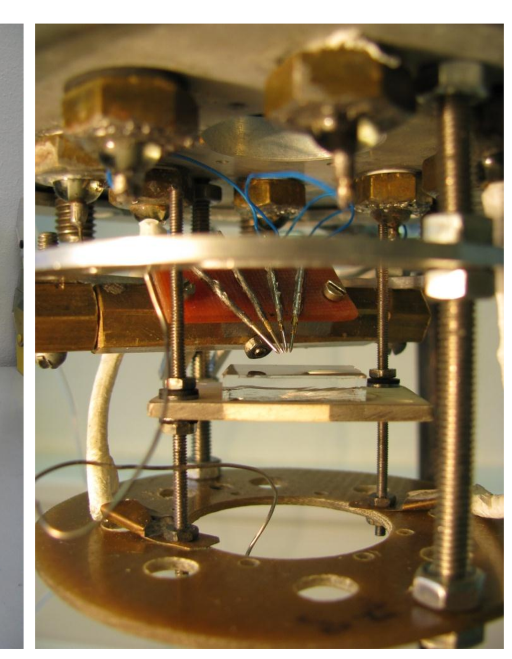


Fig. 6.: Apparatus for optimization of water vapor passivation of a thin film silicon solar cell on glass.

The following conditions is going to be tested: sample's temperature: 25° C – 300° C, temperature of water vapour: 25° C – 200° C, pressure: 5x10^3 Pa – 10^6 Pa.

In the center of my interest: Surface and bulk recombination, structural changes, potential energy height at grain boundaries, parameters – **U_{OC}, I_{SC}, MPP, R_{SS}, R_{SH}, FF, efficiency** → measuring systems at the Institute of Physics in Prague, PASAN flash system and an unlighted diagnostic system available at FEE at CTU in Prague.

CONCLUSION

Basic description of hydrogen and oxygen plasma treatments is proposed. New non-plasma passivation approach to improvement of thin film silicon solar cell parameters is presented as a potentially cheaper alternative and short overview of my next research is given.

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