HL 45.1 Wed 9:30 ER 270
Selektive Ablation dünner dielektrischer Schichten von Silizium mittels ultraschroter Laserimpulse — • Thomas Gimpel1, Martin-Luther-Universität Halle-Wittenberg, Halle (Saale), Germany — 2Fraunhofer Heinrich Hertz Institute, 38640 Goslar — • Fraunhofer Heinrich Hertz Institute, Technische Universität München, 85748 Garching, Germany

HL 45.2 Wed 9:45 ER 270
Microstructuring of silicon with femtosecond laser pulses — • Waldemar Freund1, Jan P. Richtera, Jürgen Gutowski1, and Tobias Voss1 — 1Institute of Solid State Physics, Semiconductor Optics Group, University of Bremen — 2Department of Physics, University of Grenoble

"Black silicon" has been a field of intense studies in recent years. To fabricate this material, a crystalline p-doped silicon wafer is structured with ultrashort laser pulses in a sulfurhexafluoride (SF$_6$) atmosphere. The physics on the ultrashort time scale results in two processes: the formation of laser-induced periodic surface structures (LIPPS) and the simultaneous doping of the silicon with sulfur far above the solubility limit creating a p-n+ junction which acts as a solar cell under illumination. The periodic surface structures considerably enhance light absorption in "black silicon" at energies below the silicon bandgap. The extremely high doping with sulfur results in the formation of a distinct defect band which is the origin of high absorbance in the near-infrared spectral region. Silicon treated with this process therefore constitutes a promising material for applications in thin film solar cells. We show experimental results on optimization of black-silicon cell efficiency through passivation of surface defects after treatment with HF. A significant increase in short circuit current of black silicon solar cells is observed when thinner p-silicon substrates. Our studies represent important steps towards the fabrication of efficient thin-film solar cells with increased infrared sensitivity on base of easy-to-produce black silicon.

HL 45.3 Wed 10:00 ER 270
Formation of Black Silicon by differently polarized femtosecond laser pulses — • Stefan Kontermann1, Anna Lena Baumann1, Thomas Gimpel2, Kay Michael Guenther2, Augustinas Ruhys3, and Wolfgang Schade3 — 1Fraunhofer Heinrich Hertz Institute, 38640 Goslar, Germany — 2Fraunhofer Heinrich Hertz Institute, University of Technology, Institute of Energy Research and Physical Technologies and EFZN, EnergieCampus, Am Stollten 19A, 8640 Goslar, Germany — 3Fraunhofer Heinrich Hertz Institute, Technische Universität München, 85748 Garching, Germany

Incorporated sulfur states within the silicon band gap realize n-doping and form an intermediate band which allows photons with energies below the silicon band gap to be absorbed. Nevertheless, structuring silicon by means of fs-laser pulses partially destroys the crystal structure of the monocrystalline substrates. Formation of Black Silicon by differently polarized femtosecond laser pulses in a sulfurhexafluoride atmosphere. A single fs-laser step yields a light trapping structure and the implementation of sulfur far above equilibrium concentration. Incorporated sulfur states within the silicon band gap realize n-doping and form an intermediate band which allows photons with energies below the silicon band gap to be absorbed.

Upon inductive coupled plasma reactive ion etching (ICP-RIE) of Si surfaces needle-like nanostructures with aspect ratios up to 15 are obtained. These nanostructures are interesting for application in thin film solar cells. The nanostructure is produced by a wet etching process which increases the surface area. This leads to an elevated absorption factor of up to 15 [3]. Both effects make b-Si interesting for application as an additional surface recombination needs to be minimized. Effects of different surface treatments on the surface recombination velocity will be compared. First results of diffusion length measurements and electrical detected magnetic resonance (EDMR) will be presented.


HL 45.4 Wed 10:15 ER 270
Crystal structure at the surface of femtosecond-laser-microstructured silicon for photovoltaics — • Thomas Gimpel1, Ingrid Höger2, Fritz Falk3, Stefan Kontermann4, and Wolfgang Schade1,3 — 1Clausthal University of Technology, EFZN, 38640 Goslar — 2Institute of Photoitic Technology, 07745 Jena — 3Fraunhofer Heinrich Hertz Institute, 38640 Goslar
Black Silicon structured by means of femtosecond (fs) laser pulses in a sulfur containing atmosphere is an attractive candidate for intermediate band photovoltaics. A single fs-laser step yields a light trapping structure and the implementation of sulfur far above equilibrium concentration. Incorporated sulfur states within the silicon band gap realize n-doping and form an intermediate band which allows photons with energies below the silicon band gap to be absorbed.

Nevertheless, structuring silicon by means of fs-laser pulses partially destroys the crystal structure of the monocrystalline substrates. Formation of Black Silicon by differently polarized femtosecond laser pulses in a sulfurhexafluoride atmosphere. A single fs-laser step yields a light trapping structure and the implementation of sulfur far above equilibrium concentration. Incorporated sulfur states within the silicon band gap realize n-doping and form an intermediate band which allows photons with energies below the silicon band gap to be absorbed.

Formation of Black Silicon by differently polarized femtosecond laser pulses also helps to increase the infrared absorption of this Black Silicon structure. The extremely high doping with sulfur results in the formation of a p-n+ junction which acts as a solar cell under illumination. The periodic surface structures considerably enhance light absorption in "black silicon" at energies below the silicon bandgap. The extremely high doping with sulfur results in the formation of a distinct defect band which is the origin of high absorbance in the near-infrared spectral region. Silicon treated with this process therefore constitutes a promising material for applications in thin film solar cells. We show experimental results on optimization of black-silicon cell efficiency through passivation of surface defects after treatment with HF. A significant increase in short circuit current of black silicon solar cells is observed when thinner p-silicon substrates. Our studies represent important steps towards the fabrication of efficient thin-film solar cells with increased infrared sensitivity on base of easy-to-produce black silicon.

HL 45.5 Wed 10:30 ER 270
Surface recombination in black silicon — • Michael Alcaginser, Julis Paye, Svetsloav Koynov, Martin S. Brandt, and Martin Stutzmann — Walter Schottky Institut, Technische Universität München, 85748 Garching, Germany

Black silicon passivation by conformal thermal ALD deposited $	ext{Al}_2	ext{O}_3$ coatings — • Martin Otto1, Matthias Kroll2, Thomas Käsebeier2, Roland Salzer3, and Ralf B. Weihspohn1,4 — 1Martin-Luther-University Halle-Wittenberg, 06099 Halle (Saale), Germany — 2Fraunhofer Institute for Mechanics of Materials Halle, Halle, Germany

Back Silicon structured by means of femtosecond (fs) laser pulses in a sulfur containing atmosphere is an attractive candidate for intermediate band photovoltaics. A single fs-laser step yields a light trapping structure and the implementation of sulfur far above equilibrium concentration. Incorporated sulfur states within the silicon band gap realize n-doping and form an intermediate band which allows photons with energies below the silicon band gap to be absorbed.

Nevertheless, structuring silicon by means of fs-laser pulses partially destroys the crystal structure of the monocrystalline substrates. Formation of Black Silicon by differently polarized femtosecond laser pulses in a sulfurhexafluoride atmosphere. A single fs-laser step yields a light trapping structure and the implementation of sulfur far above equilibrium concentration. Incorporated sulfur states within the silicon band gap realize n-doping and form an intermediate band which allows photons with energies below the silicon band gap to be absorbed.

The extremely high doping with sulfur results in the formation of a p-n+ junction which acts as a solar cell under illumination. The periodic surface structures considerably enhance light absorption in "black silicon" at energies below the silicon bandgap. The extremely high doping with sulfur results in the formation of a distinct defect band which is the origin of high absorbance in the near-infrared spectral region. Silicon treated with this process therefore constitutes a promising material for applications in thin film solar cells. We show experimental results on optimization of black-silicon cell efficiency through passivation of surface defects after treatment with HF. A significant increase in short circuit current of black silicon solar cells is observed when thinner p-silicon substrates. Our studies represent important steps towards the fabrication of efficient thin-film solar cells with increased infrared sensitivity on base of easy-to-produce black silicon.

In addition, the absorption at the band edge of silicon is enormously en-
hanced due to scattering. In this work we report on the feasibility to deposit conformal Al$_2$O$_3$ dielectric layers on these very rough silicon surfaces which enable adequate surface passivation. Lifetimes over 170 $\mu$s have been measured on deep structured b-Si substrates. The optical properties of black silicon (b-Si) and the possible influence of applied alumina passivation layers as well as their passivation performance are discussed.