RESEARCH ARTICLE

ADVANCED MATERIALS TECHNOLOGIES
www.advmattechnol.de

Plasma Focused Ion Beam Tomography for Accurate Characterization of Black Silicon Validated by Full Wave Optical Simulation

Yu Zhang, Tom Veeken, Shaozhou Wang, Giuseppe Scardera, Malcolm Abbott, David Payne, Albert Polman,* and Bram Hoex**

Black silicon (BSi) is a branch of silicon material whose surface is specially processed to a micro/nanoscale structure, which can achieve ultra-low reflectance or ultra-high electrochemical reactivity. The diversity and complex surface structures of BSi make it challenging to commercialize BSi devices. Modeling and simulation are commonly used in the semiconductor industry to help in better understanding the material properties, predict the device performance, and provide guidelines for fabrication parameters' optimization. The biggest challenge for BSi device modeling and simulation is obtaining accurate input surface morphological data. In this work, the 3D models of challenging BSi textures are compared as obtained by atomic force microscopy (AFM) and plasma focused ion beam (PFIB) tomography techniques. In previous work, the PFIB tomography workflow toward the application of surface topography is optimized. In this work, the 3D models obtained from both AFM and PFIB are comprehensively compared, by using the surface models as inputs for finite-difference time-domain-based optical simulation. The results provide strong evidence that PFIB tomography is a

photodiodes, photodetectors, and photovoltaic (PV) devices. A particular branch of silicon material is black silicon (BSi), the surface of which is specially processed to create a micro-/nanoscale texture.[1,2] As such, the optical performance of BSi is superior to the unprocessed silicon wafer with a planar surface, with extremely high optical absorption and low reflectance over a broad spectral range. However, due to the complex nature of the BSi surface structure, adapting the academic level BSi into a commercial device is challenging. For example, BSi with an extremely high aspect ratio will present challenges for making acceptable screen-printed contacts as used in silicon solar cells.[3] Furthermore, the increased surface area can result in inferior surface passivation.[4–6] Therefore, the state-of-the-art commercial-