# Structural characterization of $Si/SiO_2$ quantum wells by HRTEM for the solar cell application

M. Beigmohamadi[1,2], A. S. Sologubenko[3], and J. Mayer[1]

1. Central Facility for Electron Microscopy, RWTH Aachen, Ahornstraße 55, 52074 Aachen, Germany
2. Institute of Solid State Research and Ernst Ruska Centre for Microscopy and Spectroscopy with Electrons, Research Centre Jülich, D-52425 Jülich, Germany.

3. Laboratory of Metal Physics and Technology (LMPT), Swiss Federal Institute of Technology (ETH) Zürich, Wolfgang-Pauli-Strasse 10, CH-8093 Zürich, Switzerland

beig@gfe.rwth-aachen.de
Keywords: Nano-crystalline Silicon, High resolution TEM, $Si/SiO_2$ sollar cell, Quantum well

We investigate the structural properties of $Si/SiO_2$ multilayers for high-efficiency solar cells by means of high resolution transmission electron microscope (HRTEM). The analysis has been done by a FEI Titan 80-300 TEM equipped with Cs corrector and operating at 300 keV. $Si/SiO_2$ multiple quantum wells were prepared by plasma enhanced chemical vapour deposition (PRECVD) and then processed by rapid thermal annealing for Si recrystallization. To prepare a Si/SiO2 quantum well sample for cross-sectional TEM analysis, a focused ion beam (FIB) instrument was used to cut a slice through the sample and to thin the interface. The sample was further thinned with a *Fischione* model 1040 NanoMill, which removes the surface damage introduced by the initial FIB sectioning and finally cleaned by a plasma cleaning system.

It has been shown recently that the layer thickness and interface modification have considerable impact on the optical properties of this structure [1]. Therefore precise structural characterization methods like HRTEM have promoted our understanding of this Si-based tandem structure. TEM images, taken in the negative spherical-aberration imaging (NCSI) condition [2], successfully reveal the structure of the nano-crystals. Also further thinning of the sample by nanomilling technique helps to see more details by HRTEM analysis.

The HRTEM observations revealed the presence of continous nano-crystalline Si quantum-well layers with a thickness of about 4 nm encapsulated between 2 nm thick layers of amorphous $SiO_2$ (see figure 1). The resulting Si quantum wells are completely polycrystalline, which could be verified by imaging either the Si(220) or Si(111) lattice planes in all nano-crystals.

W. Grogger, F. Hofer, P. Pölt (Eds.): MC2009, Vol. 3: Materials Science,
DOI: 10.3217/978-3-85125-062-6-419 , © Verlag der TU Graz 2009

1. J.M. Wagner, K. Seino, F. Bechstedt, A. Dymiati, J. Mayer, R. Rölver, M. Först, B. Berghoff, B. Spangenberg, H. Kurz. J. Vac. Sci. Technol. A **25 (2007)**, p1500
2. C. L. Jia, M. Lentzen, K. Urban, Science 299 (2003), p870
3. Authors gratefully thank R. Roelver and B. Spangenberg from Institute for Semiconductor Technology (IHT) RWTH Aachen, for providing the samples. We would also thank *Fischione* company for preparation of the sample by NanoMill 1040. Financial support was provided by BMBF, Germany (contracts No. 03SF0308F and 03SF0352B).

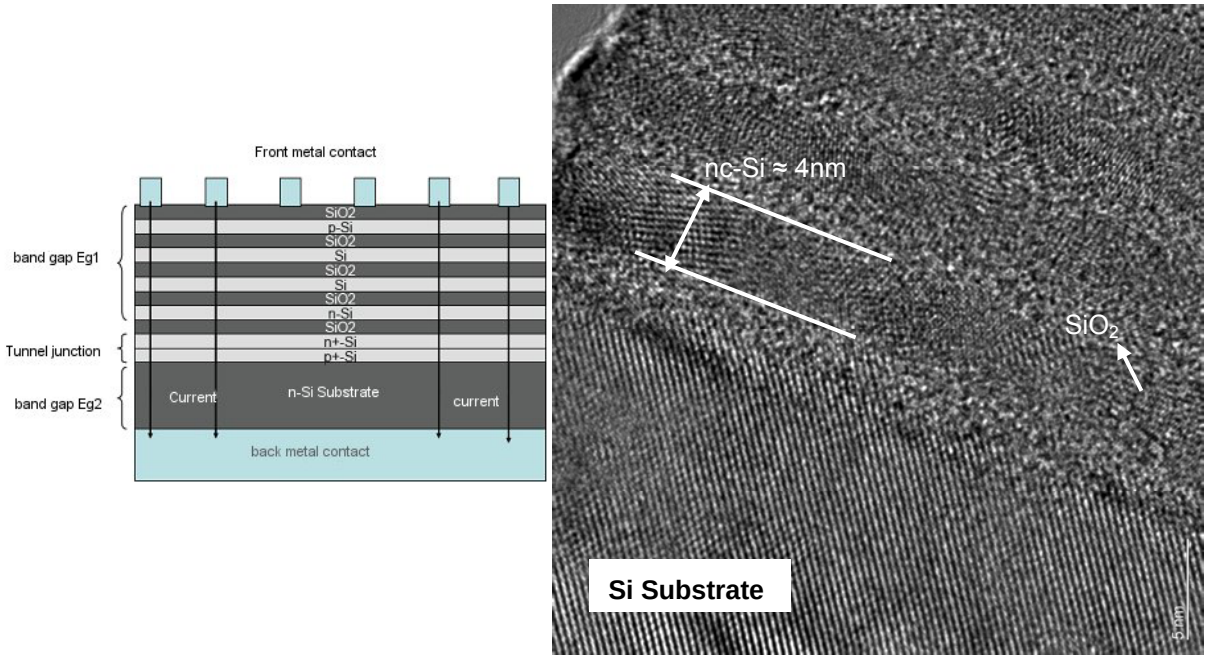


**Figure 1.** Schematic of Si-based tandem solar cell (right) and high resolution TEM analysis of a $Si/SiO_2$ multilayer quantum wells (right). The Si and $SiO_2$ layer thicknesses are about 4 and 2 nm, respectively.


DOI: 10.3217/978-3-85125-062-6-419 , 