Silicon Texturing Under Negative Potential Dissolution (NPD) Conditions

Y. Ein-Eli, N. Gordon and D. Starosvetsky
Department of Materials Engineering, Technion-Israel Institute of Technology, Haifa, 32000 Israel

J. Szlufcik, P. Choulat and F. Duerinck
IMEC, Kapeldreef 75, B-3001, Leuven Belgian

The development of a reliable and reasonably priced process of silicon texturing is of great importance in the solar cells industry (1-3). Texturing process is an important step in the manufacturing of photovoltaic panels. This process is conducted in order to reduce the reflectivity of silicon surface (1). Different methods of silicon texturing in alkaline and HF based electrolytes with the combination of photolithography were developed in the last two decades (4-6). In HF-free aqueous solutions, such as strong alkaline electrolytes, silicon is either totally passive, or actively dissolves within a narrow potential range, without any ability to regulate the etching rate (7, 8). Previous work showed that the rate of silicon dissolution in alkaline media could be significantly increased with the use of **N**egative **P**otential **D**issolution (NPD) [cathodic polarization]. Not only that acceleration in silicon dissolution rate was established but also silicon surface was smoother (up to a polish degree) with a negative shift in the cathodic potential (9, 10).

In the present work we used **N**egative (cathodic) **P**otential **D**issolution (NPD) as a tool in the electrochemical texturing of silicon (11). We also looked for the accurate conditions (potential, electrolyte concentration, time) suitable for silicon texturing under NPD process. This work presents results related to silicon texturing obtained under NPD conditions from <100>, <110> and <111> p-type silicon in a wide cathodic potential region in different concentrations of alkaline solution and time periods.

The effect of the NPD on p-type silicon (orientations of <100>, <110> and <111>, 8-12 Ω-cm) topography was studied in 16-32 (wt. %) potassium hydroxide (KOH) solutions at 20 °C. The solutions were circulated in the electrochemical cell (1.5 litters) with the use of a peristaltic pump. Experiments were conducted in electrochemical cell containing a Teflon holder equipped with an O-ring. HP 762 power supply was used in a constant potential mode. The potentials applied at the tested silicon electrodes were measured with the use of a Luggin capillary and a saturated calomel reference electrode (SCE), while a platinum wire was used as a counter electrode. The cathodic polarization was applied only when the potential of the silicon sample reached steady-state values (usually around -1.15 V). The potentials values varied between -10 V and -100 V vs. SCE . Subsequent to the NPD process the surface of the tested silicon was evaluated with the use of Scanning Electron Microscopy (S Geminate FEG-HRSEM).

Acknowledgement

This research work was funded by the EC PF5 under contract No. ENK CT2001 00561 FANTASI.

References

1. H. Seidel, L.Csepregi, A. Heuberger, H. Baumgartel, *J. Electrochem. Soc*., **137**, 3612 (1990).

2. T.A. Kwa, P.J. French, R.F. Wolffenbuttel,, P.M. Sarro, L. Hellemans and J. Snauwaert, *J. Electrochem. Soc*., **142**, 1226 (1995).

3. C.R. Tellier and A. Brahim-Bounab, *J. Mater. Sci*., **29**, 5953 (1994).

4. X. G. Zhang, ***Electrochemistry of Silicon and its Oxide***, Chapter 7, pp. 279-349, Kluwer Academic/Plenum Publishers, New-York, 2001.

5. M.A. Green, Advanced in Solar Energy, vol. 8, M. Prince (Ed.), American Solar Energy Society, Boulder, CO, p.231, 1993.

6. M.A. Green, J. Zai, A. Wang, S.R. Wenham, IEEE Electron Dev. *Lett.* EDL-13 317 (1992).

7. P. Allongue, V. Costa-Kieling , H. Gerischer, *J. Electochem. Soc.*, **140**, 1009 (1993).

8. O.J. Glembocki, R.E. Stahlbush, M. Tomkieicz, *J. Electochem. Soc.* **132**, 145-151 (1985).

9. M. Kovler, D. Starosvetsky, Y. Nemirovsky, J. Yahalom, *Proceedings of The Materials Research Society Symposium*, December 1-2, 1998, Boston, Massachusetts, USA, V. 546, MRS, WARRENDALE, Pennsylvania, p. 75, 2000.

10. D. Starosvetsky M. Kovler, J. Yahalom and Y. Ein-Eli, *SOTAPOCS 37 Symposium*, Extended Abstract 582, 202nd Fall Meeting of The Electrochemical Society, UT 2002.

11. Y. Ein-Eli and D. Starosvetsky, *Electrochem. and Solid-State Letters*, (**in press**, 2003).