Research group of P. Schmuki:

- **Sensitization of semiconductor surfaces for totally selective electrochemical reactions**

In a collaboration with the National Research Council of Canada it has been shown that red light emitting porous Si can be produced at defined surface locations of a Si substrate by a direct writing process using focused ion beam technology combined with electrochemistry [1], see Fig. 4.4.6.1.

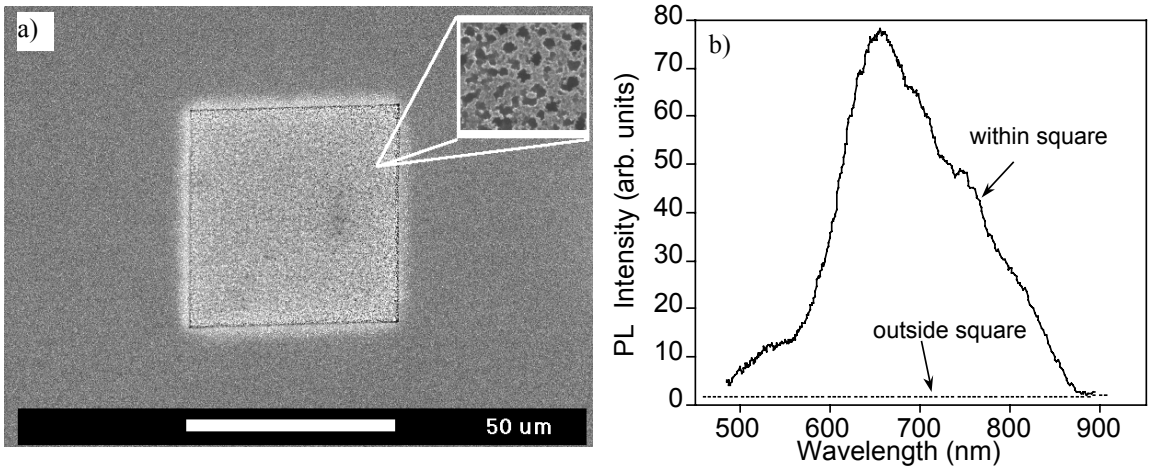

Fig. 4.4.6.1: Selective formation of red-light emitting porous Si on a FIB implanted area. a) SEM image of a 50 x 50 µm square implanted with 3 x 10^{14} cm^{-2} Si^{++} (200 keV) after polarization in 20% HF from -0.5 V to 3.5 V. Inset shows higher magnification of the porous Si structure within the square. b) Room temperature photoluminescence spectra acquired in the center of the square and on adjacent area.

The principle is that the growth of porous Si growth can electrochemically be initiated preferentially at surface defects created in a single crystal Si substrate by ion bombardment. Using a focused ion beam (FIB) as a source of ions, arbitrary defect patterns in the 50 nm to 200 nm range can be written into a substrate, compare Fig. 4.4.6.2. The selectivity of the subsequent electrochemical dissolution reaction seems to be due to a facilitated Schottky barrier breakdown at the implanted surface defects which leads to the desired "localized current flow".

In more general terms this preliminary work shows the feasibility of a new principle for locally activating or sensitizing a semiconductor surface for a subsequent chemical or electrochemical reaction. This principle is not only applicable to trigger the growth of porous Si structures on pre-defined and confined surface locations but can also be exploited for highly localized direct electrochemical deposition reactions [2]. This provides the basis for

much wider applications in surface physics, chemistry and materials science, as deposition of all materials that currently can be electrodeposited on a larger scale (metals, other semiconductors or ceramics) should be possible in a submicron scale.

Further work will investigate this local porous semiconductor formation mechanism in detail (including recently discovered light emitting porous GaAs [3,4]). On the other hand, key factors and perspectives of local electrodeposition processes will be studied.

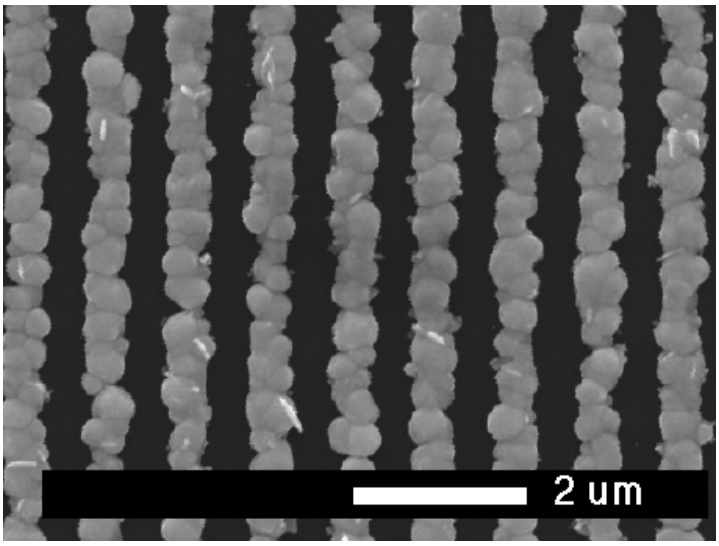

Fig. 4.4.6.2: Selective Au deposition on Si sensitized with FIB lines.

References:

[1] P. Schmuki, L.E. Erickson, D.J. Lockwood, Light emitting micropatterns of porous Si created at surface defects; Phys. Rev. Lett. **80** (1998) 4060

[2] P. Schmuki, L.E. Erickson, Selective deposition of metal nano-patterns on silicon; Phys. Rev Lett. **85** (2000) 2985

[3] P.Schmuki, D.J. Lockwood, H.J. Labbe, J.W. Fraser, Visible photoluminescence from porous GaAs; Appl. Phys. Lett. **69** (1996) 1620

[4] P. Schmuki, L.E. Erickson, D.J. Lockwood, J.W. Fraser, G. Champion, H.J.Labbe, Formation of visible light emitting porous GaAs micropatterns; Appl. Phys. Lett. **72** (1998) 1039