Macroporous silicon (Fabrication)

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Introduction

pMacroorous silicon develops if silicon is anodically biased and electrochemically etched in hydrofluoric acid (HF). Especially for n-type silicon this is nowadays a well known process. Macroporous silicon with its high perfectness represents an ideal 2D photonic crystal exhibiting novel properties for the propagation of infrared light inside.

Regular pore formation

Using lithographic prestructuring the nucleation spots of the pores can be defined at the surface of a (100)-oriented n-type silicon wafer. This allows to determine a periodic pore pattern and to control the lattice constant of this pore lattice over a large range between 8 µm and 0.5 µm. During the etching process the backside of the n-type wafer must be illuminated to create electronic holes via light absorption in the silicon. They diffuse from the backside to the etch front and are consumed for the electrochemical etching process almost exclusively at the pore tips. The pore walls are protected against electrochemical dissolution by a space charge region originating from the silicon/electrolyte contact (**Fig. 1**). This process results in a periodic array of straight air pores in silicon. Due to electrochemical passivation of the pore walls very high aspect ratios (ratio between pore length and pore diameter) of 100-500 are obtained.

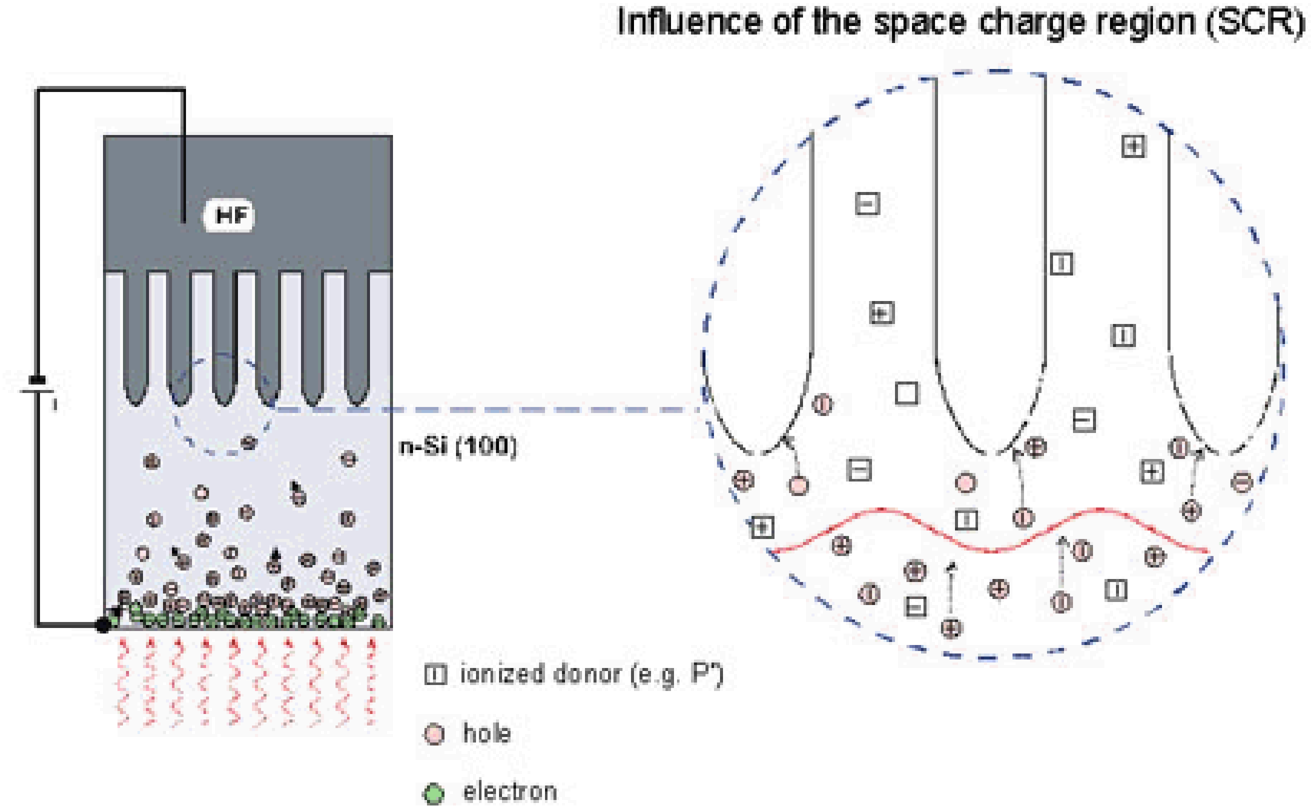

Fig. 1. Photo-electrochemical etching of silicon; macropore formation.

Defect engineering

Omitting single holes or a line of holes in the lithographic prestructuring directly results in single missing pores or lines of pores in the porous film. Samples with such missing pores are shown in Fig. 2. Because of their application in photonic crystals they are called defects (see photonic crystals section).

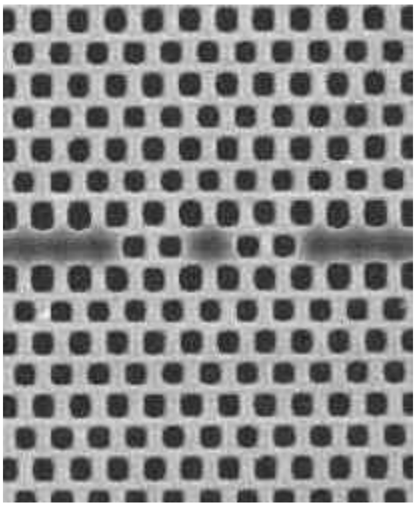

Fig. 2a. Point defect.

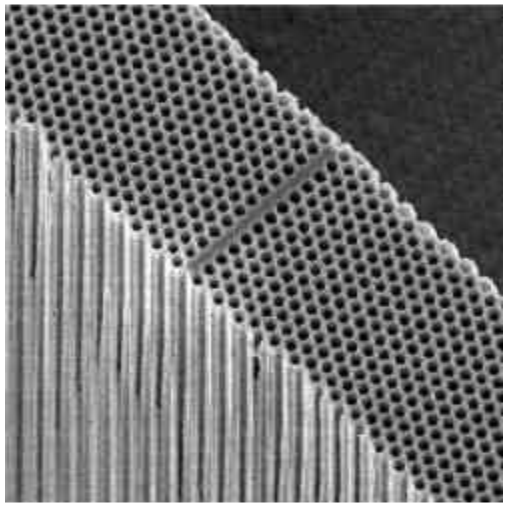

Fig. 2b. Line defect.

Diameter modulation

Besides the lateral lithographic structuring also a structuring along the pore axis is possible: The diameter of the pores depends on the etching current which is controlled by the rate of hole generation. A periodic variation of the backside illumination therefore results in a periodic variation of the pore diameter with the pore depth. Applications of these diameter-modulated pores are 3D photonic crystals and drift ratchets.

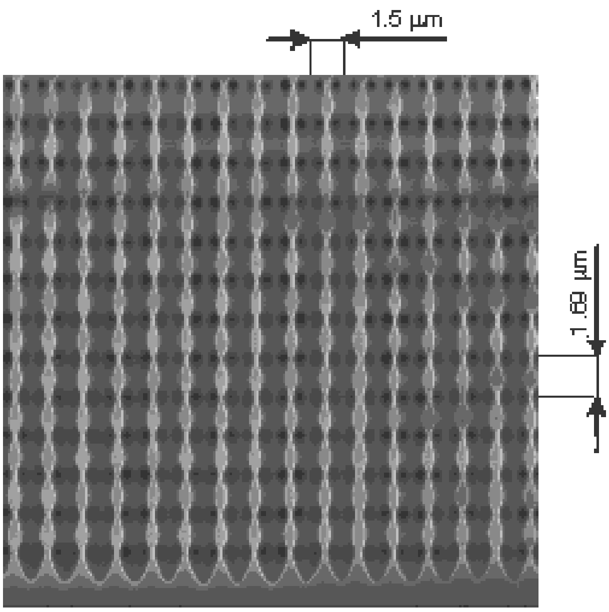

Fig. 3. SEM cross-section image of modulated pores.

In the meantime, the 3d-shaping has been improved considerably towards the fabrication of simple cubic photonic crystals with a complete photonic bandgap.