P-형 실리콘에 형성된 정렬된 매크로 공극

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Ordered Macropores Prepared in p-Type Silicon

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Abstract : Macrofore formation in silicon and other semiconductors using electrochemical etching processes has been, in the last years, a subject of great attention of both theory and practice. Its first reason of concern is new areas of macropore silicone applications arising from microelectromechanical systems processing (MEMS), membrane techniques, solar cells, sensors, photonic crystals, and new technologies like a silicon-on-nothing (SON) technology.

Its formation mechanism with a rich variety of controllable microstructures and their many potential applications have been studied extensively recently. Porous silicon is formed by anodic etching of crystalline silicon in hydrofluoric acid. During the etching process holes are required to enable the dissolution of the silicon anode. For p-type silicon, holes are the majority charge carriers, therefore porous silicon can be formed under the action of a positive bias on the silicon anode. For n-type silicon, holes to dissolve silicon is supplied by illuminating n-type silicon with above-band-gap light which allows sufficient generation of holes. To make a desired three-dimensional nano- or micro-structures, pre-structuring the masked surface in KOH solution to form a periodic array of etch pits before electrochemical etching. Due to enhanced electric field, the holes are efficiently collected at the pore tips for etching. The depletion of holes in the space charge region prevents silicon dissolution at the sidewalls, enabling anisotropic etching for the trenches. This is correct theoretical explanation for n-type Si etching. However, there are a few experimental repors in p-type silicon, while a number of theoretical models have been worked out to explain experimental dependence observed.

To perform ordered macrofore formaion for p-type silicon, various kinds of mask patterns to make initial KOH etch pits were used. In order to understand the roles played by the kinds of etching solution in the formation of pillar arrays, we have undertaken a systematic study of the solvent effects in mixtures of HF, N-dimethylformamide (DMF), iso-propanol, and mixtures of HF with water on the macrofore structure formation on monocrystalline p-type silicon with a resistivity varying between 10 ~ 0.01 Ω cm. The etching solution including the iso-propanol produced a best three dimensional pillar structures. The experimental results are discussed on the base of Lehmann's comprehensive model based on SCR width.

Key Words : p-type Si, macropore, KOH etching, SCR, electrochemical etching