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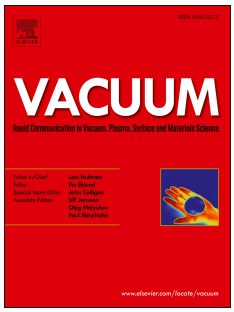

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Mechanical characteristics of hydrogen-implanted crystalline silicon after post-implantation annealing

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Abstract

Knowing the mechanical properties of single crystal silicon after implantation with hydrogen and annealing are important for "smart cut" process and in improving ultra-precision cutting of silicon. There is limited information on hardness and modulus of such silicon. In this article, the effect of hydrogen implantation dose and post-implantation annealing on silicon hardness and modulus were investigated. Continuous implanted silicon layers, from the surface to the depth of ~500 nm, were produced. Samples with three different implantation doses and with post-implantation annealing at 350 ^{o}C and 400 ^{o}C were prepared. Hardness and modulus were obtained through dynamic nanoindentation, while structural properties were evaluated by Rutherford backscattering spectroscopy and high resolution x-ray diffraction. Hardness and modulus were significantly reduced after annealing for the highest implantation dose. With the annealing, the implantation-induced strain had the least relaxation for the lowest implantation dose. The obtained results could be useful for understanding the role of hydrogen in nano-cutting of hydrogen-implanted silicon.

Keywords: elastic modulus; hardness; silicon; hydrogen implantation; Rutherford Backcattering Spectroscopy; high resolution XRD;

1.Introduction

Hydrogen has significant technological importance in single crystal silicon in improving electrical performance of MOSFETs by terminating the dangling bonds at the interface gate oxide-silicon [1]. However, the focus in this article is a modification of the mechanical properties of silicon with hydrogen and it's effects on two applications. (i) Hydrogen is crucial in so-called "smart cut" process for silicon on insulators (SOI) technology [2-7]. In the latter, hydrogen implantation depth controls the desired thickness of the semiconductor layer in SOI structure. (ii) Silicon optical devices can be fabricated by ultra-precision machining. It is well known that Si is difficult to machine because of it's high hardness and brittleness. Recently, it was shown that implanted hydrogen can improve nano/micro machinability of silicon [8,9].