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Features of FeB pair light-induced dissociation and repair in silicon n^+-p-p^+ structures under ultrasound loading

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ABSTRACT

The experimental research in ultrasound impact on iron–boron pair transformation in silicon n^+-p-p^+ structures has revealed the decrease in concentration of pairs dissociated by light, as well as in the time of pair associations. The FeB pair changes were monitored by measuring short circuit current kinetics. The ultrasound influence was investigated at different light intensities, temperatures, frequencies, and power of acoustic waves. The possible mechanisms underlying the revealed effects were analyzed.

I. INTRODUCTION

It is widely known that the properties of semiconducting crystals and structures are determined very much by their impurity compositions. As a result, the methods aimed at modifying the system of defects are very important for practical applications. Most of these methods use irradiation, thermal treatment, or specific conditions of crystal growth. However, numerous experiments show that ultrasound also represents a sufficiently effective instrument to control the semiconductor defects. For example, it has been found that acoustic waves cause a spatial redistribution of defects,[1–6] transformation of metastable point defects,[7–9] recharging of recombination centers,[10,11] and low temperature annealing of radiation defects.[12–16] The effects of this kind are observed in silicon in particular, which is the basic modern material used in microelectronics and solar power engineering.[1,2,5,8,12,15,17,18]

The advantages of using active ultrasound (US) are the local action of elastic oscillations and the possibility to adjust the external impact by changing the type, polarization, or frequency of acoustic waves.[19] However, this method of modifying defect systems has not found wide application not least because of the lack of appropriate experimental research. In our opinion, it is most promising to use US loading (USL) as an additional factor of influence during various technological processes, which causes, in particular, the transformations in the defect system. This assumption is supported by the results obtained during ion implantation performed in the US field.[1,17,20]

Iron is an important impurity in silicon-based integrated circuit and solar cell technology. Most often, iron-related defects are the main recombination centers that determine the lifetime of minority charge carriers in particular, and device characteristics in general. Therefore, the methods aimed at iron gettering at various stocks have practical importance. There are quite many reports concerning defects of this kind. It is known that in thermal equilibrium at room temperature virtually all Fe_i is present as Fe_iB_s pairs in Si:B.[21,22] FeB pair dissociation can be accomplished by illumination at room temperature, by minority carrier injection, or by increasing the temperature.[21,23,24] Moreover, ultrasound vibrations with a frequency of 25–80 kHz and acoustic lattice strain of 10^{-5}–10^{-4} (Cz–Si[25]) or 10^{-6}–10^{-5} (poly-Si[26,27]) are capable of destroying FeB pairs. In practice, however, the most widely used technique is light-induced dissociation. The peculiarities of the dissociation and subsequent repair are well studied.[21–23,28–33] However, to the best of our knowledge, there are no reports about the US impact on these processes.