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Plasma-Based Low Energy Ion Implantation[1]

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After intense research and development of plasma doping systems, successful application of pulsed glow discharge in low energy ion implantation has been demonstrated. This approach offers great potential for both economic benefit, as a much higher throughput process than traditional beam line implantation, as well as enabling new fabrication options for advanced CMOS or non-planar implant. Understanding the discharge physics - collisions, ion energy distributions, plasma composition, secondary electron emission in the sheath of the dc pulsed plasma is indispensable for controlling the low energy ion implantation process. In this paper, ion energy distribution is directly measured from the high voltage sheath in a pulsed dc glow discharge using BF3 or BF3 mixed with inert gases as a gas feedstock. The impact of the ratio of BF3 mixed with inert gases on the ion energy distribution of the different ions and plasma parameters in the bulk and in the sheath is studied. The effects of elastic and inelastic collisions in the sheath on the ion energy distributions were experimentally and theoretically determined. It was found in several experiments that molecular ion such as BF2+ dominates the BF3 glow discharge. A possibility of negative ion formation is discussed with the recent experimental results taken into account. The analysis of the ion energy distribution and plasma parameters enabled a better understanding of the key parameters that control the nature, the concentration and the depth distribution of the implanted species. Based on the ion energy distributions measured with the mass spectrometer, the dopant depth profile is predicted and the plasma parameters are optimized in order to obtain shallow dopant depth distribution in the silicon after plasma doping implantation. This review of pulsed plasma-based implantation for semiconductor applications will focus on plasma diagnostics results thus far and the prospects for low energy implant applications.

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