World Academy of Science, Engineering and Technology
International Journal of Materials and Metallurgical Engineering
Vol:19, No:02, 2025

# Delta-Doping in Silicon by Argon Ion Pre-implantation and Nanosecond Laser Annealing

**Authors :** Zhengfang Fan, Yaping Dan

**Abstract :** Delta-doping (δ-doping) has extensive applications in advanced metal oxide semiconductor field effect transistors, quantum devices and deep ultraviolet photodetectors. In this work, we demonstrate a novel method to form high-concentration phosphorus δ-doping in silicon with the assistance of argon pre-implantation and nanosecond laser annealing. It is encouraging that argon pre-implantation dramatically increases the incorporation of P dopants by 1-3 orders of magnitude, depending on the dosage of argon pre-implantation. The δ-doping layer in silicon has a peak phosphorus concentration of 1.44 × 1020 cm-3. Hall measurements reveal that the argon pre-implantation significantly increases the electron concentration, resulting in metallic-like conductivity in the δ-doping silicon layer. The magnetoresistances of the δ-doping samples decrease as the perpendicular magnetic field increases due to the weak localization of electrons, which implies the formation of a two-dimensional electron gas. As a demonstration, a highly sensitive deep ultraviolet photodetector is fabricated by forming an n-type δ-doping layer on a p-type Si substrate. A photocurrent of 0.33 μA is generated in the fabricated deep ultraviolet photodetector under the illumination of light at a wavelength of λ = 280 nm and the intensity of 266 μW/cm2, showing that the responsivity of the device is 0.124 A/W, two times of a commercial Si photodiode (LSSPD-U1.2, Beijing Lightsensing Technologies Ltd). This combination of argon pre-implantation and laser annealing offers a promising route for the realization of δ-doping layer in silicon, with potential applications in a variety of electronic and optoelectronic devices, including high-speed transistors, photodetectors, and quantum devices.

**Keywords :** argon pre-implantation, delta doping, laser annealing, two-dimensional electron gas
**Conference Title :** ICMPT 2025 : International Conference on Materials Processing Technology
**Conference Location :** Phuket, Thailand
**Conference Dates :** February 24-25, 2025