Phosphorus-Doped N-Type Diamond Semiconductors through High-Pressure Thermal Diffusion

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Abstract

Diamond is known as the ultimate semiconductor due to its outstanding physical properties. However, the dense carbon atomic arrangement in its lattice and the relatively large doping atom radius make n-type doping highly challenging and result in poor electrical performance, which remains a major technical bottleneck for the application of diamond semiconductor materials. The report will introduce the high-pressure thermal diffusion method for n-type doping of diamond single crystals, which employs a high-pressure environment to significantly reduce the volume difference between phosphorus atoms and carbon atoms in the diamond lattice. The proposed high-pressure thermal diffusion method can achieve effective doping and ionization of phosphorus atoms in the lattice of diamond. The prepared phosphorus doped diamond exhibits the lowest resistivity (2 Ω.cm) and highest electron concentration (2.3×10^{18} cm^{-3}) observed in any known phosphorus doped diamond single crystal at room temperature. The high-pressure thermal diffusion method will provide an effective new technology for n-type doping of diamond, which is expected to play an important role in the design and preparation of diamond based semiconductor devices in the future.