n-type diamond- experimental findings and theoretical predictions

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Abstract:
One of the major issues in diamond electronics is the search for a useful n-type dopant.
Nitrogen is a well-known, yet very deep (Ea=1.7 eV), donor in diamond. Phosphor has been shown to be a donor in diamond, yet with a rather deep level (E_a~ 0.6 eV) and (still) with low electron mobilities. Interstitial group I elements (Li, Na) have been predicted to act as donors in diamond but have, so far, not yielded any convincing, useful electron conductivities.
Reports that sulfur is a donor in diamond with a rather shallow level (Ea=0.37 eV) have caused much excitement. It was, however, shown that B contamination is often unintentionally introduced during CVD S doping attempts, and its presence over shadow the n-type features due to the S dopant
Attempts to dope diamond with P and with S by ion-implantation have not yet yielded n-type conductivities which can be related solely to the dopant activation. On the other hand, point defect related electrical conductivity in diamond (as induced by ion or electron irradiation) was shown to act as compensating donors to B doped diamond, and has been proven to yield rectifying junctions with p-type diamond.
Most recently co-doping of a donor atom (S or P) with other impurities (B or H) have shown shallow n-type features. These most exciting results need still to be further studies.
Computer simulations of diamond containing different potential donor impurities yield contradicting results as for the solubility and the ionization energies of the donor levels.

The experimental and theoretical status of doping diamond n-type will be critically reviewed.