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IS634: First results on the temperature dependence of the ^{11}Be lattice location in GaN

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The interest in Be in GaN stems from the challenge to understand why it is technologically feasible to dope this wide band gap semiconductor *p*-type with Mg, while this does not work for Be. While theory has actually predicted an acceptor level for Be that is shallower than Mg [1,2], it was also argued that Be would not be a suitable acceptor because its amphoteric nature, i.e. its tendency to occupy both substitutional Ga and interstitial sites, would be considerably more pronounced than for Mg and hence lead to complete self-compensation [2].
Using the Emission Channeling with Short-Lived Isotopes (EC-SLI) technique, we determined the lattice location of ^{11}Be ($t_{1/2}$=13.8 s) in several doping types of GaN as a function of implantation temperature.
We found that interstitial ^{11}Be fractions were much higher than for ^{27}Mg, which confirms that indeed self-compensation should be considerably more pronounced for Be than for Mg. In addition there was much less influence from implantation damage for ^{11}Be than for ^{27}Mg, hence the above mentioned fractions could also be measured for longer implantation times. ^{11}Be is therefore a more convenient "probe for the Fermi-level" than ^{27}Mg.
Site changes of interstitial Be(i) to substitutional Be(Ga) started around 400°C in undoped GaN and *n*-GaN:Si, thus roughly at the same temperature as for ^{27}Mg. This is a bit of a surprise since the interstitial Be seems to show a similar migration energy as Mg, somewhat in contrast to theoretical predictions [2,3,]. In *p*-GaN:Mg the site change of ^{11}Be also started at 400°C, however, Be did then not completely disappear from interstitial sites, but was only reduced to ˜15%, then there was a clear second stage at 750°C, so that only at 800°C Be(i) was completely converted to substitutional. Our best guess so far is possible formation of Be(i)-Mg(Ga) pairs that slow down Be(i) diffusion until these pairs are broken up.

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