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A study of vacancy-type defects in wide-gap semiconductors by means of positron annihilation spectroscopy

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Positron annihilation is a non-destructive tool for investigating vacancies in materials. A positron annihilates with an electron and emits gamma rays in solids. Their energy distribution is broadened by the momentum component of the annihilating electrons. A positron could be trapped by a vacancy because of Coulomb repulsion from ion cores. Because the momentum distribution of the electrons in the defects differs from that of electrons in the bulk, the defects can be detected by measuring the energy distribution of the annihilation radiation. The electron density in vacancies is lower than that in the bulk, which increases the lifetime of positrons. Thus, the measurement of positron lifetimes is also a useful method to detect vacancies.
Using monoenergetic positron beams constructed at University of Tsukuba and TUM FRMII (NEPOMUC), we have characterized vacancies in Mg implanted GaN. Depth distributions of the defects, their annealing behaviors, and interactions with impurities were studied to achieve p-type GaN using ion implantation. The carrier trapping phenomena by vacancies were also studied. A study of native defects in AlN and their introduction mechanisms during the growth will be also presented in the talk.
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