Contribution ID: **40** Type: **not specified**

GaN-InGaN multiple quantum well (MQW): superfast semiconductor scintillator for time tagging in composite pixels for TOF-PET

Saturday, June 4, 2022 1:30 PM (15 minutes)

To improve timing coincidence resolution to the time scale of few tens of picoseconds in future generations of TOF-PET, among others, scintillator material producing more light in subnanosecond time scale is needed. Semiconductors with Wannier exciton emission in quantum confinement regime are an option as their radiative lifetimes can be shortened down to subnanosecond time scale thanks to the microscopic superrradiance effect. These luminescence phenomena are studied for more than 40 years. In bulk semiconductors, given the nature of this kind of excitonic emission, there is very small Stokes shift which results in huge reabsorption in cases when optical path of generated luminescence is of about just few mm. This problem can be solved by thin QWs with redshifted emission energy with respect to the surrounding material. Among direct band semiconductors the nitrides, such as AlGaN, GaN or InGaN, offer the advantage of high binding energy of exciton which is necessary to prevent ionization losses (exciton disintegration) around room temperature. InGaN/GaN QWs can significantly enhance fast excitonic emission. Their emission wavelength can be tuned by In content and wells dimension within 400-450nm. Radiative lifetimes are of the order of 1 ns with negligible ionization losses around room temperature. The main technological challenge is to achieve sufficient total thickness of MQW to share reasonable amount of the absorbed energy of incoming 511keV photons and to suppress the visible defect emission which is slow and competes with fast excitonic one.
We will discuss potential of GaN-InGaN multiple quantum well scintillators (MQW) for TOF-PET detector where this material would constitute a „fast part“ of a composite pixel.

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Session Classification: Technologies for ≤100ps TOFPET resolution: Scintillators

Track Classification: Technologies: Scintillators