

**DEVELOPMENT OF OVER-1000 nm NEAR INFRARED (OTN-NIR)
-FLUORESCENT NANOPHOSPHORS AND APPLICATION FOR LAPAROSCOPIC
CANCER SURGERY**

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The use of near infrared (NIR) light for biomedical photonics in the wavelength region between 800 and 2000 nm, which is called "biological window", has received particular attention since water and biological tissues have minimal optical loss due to scattering and absorption in this region. Recent development of InGaAs CCD enables observations in this region. Here we report development of rare earth ion-doped ceramic nanoparticles (RED-CNP) for OTN (over-1000 nm) NIR bioimaging, which show strong NIR emission under NIR excitation, and application in laparoscopic cancer surgery using model swine.

Yb and Er-doped yttrium oxide nanoparticles ($Y_2O_3:YbEr$ -NP, 130 ± 25 nm) were prepared for OTN-NIR bioimaging. Fluorescence spectra indicates that $Y_2O_3:YbEr$ -NP showed NIR emission at 1550 nm with NIR excitation at 980 nm. We also demonstrate that NIR emission can be observed through tissues such as swine colon, indicates that NIR emission intensity from $Y_2O_3:YbEr$ -NP is strong enough to be observed from outside tissue.

Application of OTN-NIR photonic nanomaterials for the intraoperative recognition of the tumor site in laparoscopic surgery for the gastrointestinal cancer is proposed. Tattooing into the submucosal layer of the colon is generally performed in laparoscopic surgery. However, it sometimes leads to difficulty in recognition of cancer site due to faint tattoo and diffused tattoo, which causes spread resection of the colon. In our proposed method, RED-CNP-coated materials such as medical clips (NIR clip) are used to mark cancer site with endoscopy. Cancer site can be recognized during cancer surgery through the intestinal wall by NIR fluorescence from the NIR clips fixed inside the colon using NIR-NIR imaging system. Here we demonstrate that determination of the proper resection margins for curative resection during surgery is possible using model swine, which is much more advantageous compared with the current procedure using tattoo.

References:

[1] K. Soga et al., "Application of ceramic phosphors for near infrared biomedical imaging

- technologies" *Proc. SPIE*, **7598**, 759807-1-759807-9 (2010).
- [2] T. Zako et al., "Development of Near Infrared-Fluorescent Nanophosphors and Applications for Cancer Diagnosis and Therapy" *J. Nanomater.* **2010**, 1-8 (2010).