

Spectroscopic properties of Y_2SiO_5 single crystals doped with Yb^{3+} ions for quantum memory applications

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Y_2SiO_5 crystal is an effective host material for rare earth dopants [1]. $^{171}\text{Yb}^{3+}:\text{Y}_2\text{SiO}_5$ single crystals grown by the Czochralski method are considered as promising systems for quantum technologies [2]. In this work Y_2SiO_5 single crystals doped with various concentrations of Yb^{3+} ions were grown using μ -PD technique [3,4]. The phonon energy of $\text{Y}_2\text{SiO}_5:\text{Yb}^{3+}$ single crystals were characterized using μ -Raman spectroscopy. The absorption spectrum $\text{Y}_2\text{SiO}_5:\text{Yb}^{3+}$ displays a pronounced band centred at 978.44 nm, characteristic of the $^2\text{F}_{7/2} \rightarrow ^2\text{F}_{5/2}$ transition of Yb^{3+} in an oxide host. In addition to this near-infrared absorption, broad absorption bands centred at approximately 571, 601, and 663 nm are observed. These bands exhibit full widths at half maximum of about 40 nm, and their intensities increase systematically with increasing Yb^{3+} concentration. Emission spectra were measured using an FLS1000 spectrophotometer with Xe-lamp excitation. The emission intensity depends on the position along the crystal rod from which the sample was cut. A clear trend is observed for samples doped at 50 ppm of Yb^{3+} ions: the emission and excitation intensities are highest for the sample taken from the beginning of the rod, intermediate for the central part, and lowest for the sample taken from the later growth stage. The same observation concerns the excitation spectra. The same positional dependence is observed in the emission decay time measurements. The decay curves can be reasonably described by mono-exponential functions, although the average lifetimes obtained using different fitting approaches show slight variations. These differences remain small and are not considered significant within the experimental uncertainty.

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