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Photoluminescence of Nd-doped TiO2 Thin Films by Laser Ablation

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Rare-earth (RE) doping of semiconductors [1-4] has attracted much attention for the development of optoelectronic devices initiated by the report on the photoluminescence (PL) centered at around 1540 nm of Er^{3+} ($^4I_{13/2} \rightarrow {}^4I_{15/2}$) in Si [1]. The wide-band-gap materials such as ZnO and TiO_2 with the band-gap energy of approximately 3.3 eV have been focused as the candidates of host materials for RE doping because of the enhancement of RE-related luminescence [2]. There has been much interest in neodymium (Nd) ions among RE ions since the light emissions are centered at 880, 1060, and 1320 nm. Here, we investigated the synthesis of Nd-doped anatase TiO_2 (A-TiO_2:Nd) and rutile TiO_2 (R-TiO_2:Nd) thin films by laser ablation. The PL properties of the TiO_2:Nd films and the excitation process of Nd^{3+} emission were also discussed. Laser ablation technique is simple and useful for doping the RE elements into the host materials [3]. A- and R-TiO_2:Nd films with approximately 200 nm thick were synthesized on Si(100) substrates at room temperature by the control of O_2 pressure during the ablation. The Nd doping concentration in the films was estimated to be 1.5×10^{20} cm^{-3}. Intense and sharp Nd^{3+}-related PL was observed in the range from 8 K to room temperature. The observed PL peaks at 915, 1094, and 1384 nm are due to the transitions from the $^4F_{3/2}$ to the $^4I_{9/2}$, $^4I_{11/2}$, and $^4I_{13/2}$ states of Nd^{3+}, respectively. From the PL and PL excitation spectra, it was found that Nd^{3+} emissions result from the indirect excitation of Nd^{3+} through the energy transfer of electron-hole pairs created in the TiO_2 host.

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Keywords
laser ablation
rare-earth doping
neodymium
titanium dioxide films
photoluminescence