Multiphonon-assisted lasing beyond the fluorescence spectrum in Yb:YCOB crystal

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Laser is an artificial coherent light with high brightness and high intensity. Its invention and rapid development have profoundly changed our industrial production and daily life, thus providing a powerful tool for understanding and reforming our world. For a long time, stimulated emission is inherently linked to spontaneous emission, and one would therefore expect the lasing emission to be limited to the spectral range of the fluorescence spectrum of the active material. Therefore, the fluorescence spectrum range has been considered as a crucial parameter for evaluating the performances of laser materials. At present, laser wavelengths beyond the fluorescence spectrum can only be achieved with indirect conversion methods based on high-order nonlinear optics, but suffer from complicated configurations, direction sensitivity and high costs. Accordingly, the discovery of new laser generation mechanism and direct laser availability beyond the fluorescence spectrum have always been a hotspot in the laser crystal and laser physics field.

We proposed a novel multiphonon-electron coupling mechanism to access this aim. The laser emission far beyond the spontaneous emission was realized by coupling electron transitions with the mechanical vibrations of the atoms in the laser material. A physical model of multiphonon coupling was built and a crucial functional unit of "free-oxygen" for strengthening the electron-phonon coupling was discovered in the Yb-doped $YCa_4O(BO_3)_3$ crystal [1, 2]. Then, a segmentally tunable laser emission involving a various number of phonons was obtained from 1110-1465 nm, far beyond the intrinsic fluorescence spectrum more than 400 nm. As expected, the efficiency of the system decreases with the number of phonons involved from a maximum of 41% with three phonons to 0.3% with a maximum of seven phonons involved at 1436 nm. Moreover, a similar laser performance was realized in another active material (a Yb-doped $La_2CaB_{10}O_{19}$ crystal), demonstrating that the same principle can be applied in other laser materials to extend the laser spectrum.

References

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