OPTICAL FUNCTIONING GLASS AND APPARATUS USING THE SAME

This is a division of application No. 07/829,477, filed Feb. 3, 1992, now U.S. Pat. No. 5,244,846.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical functioning glass, an optical fiber, an optical waveguide device, and an optically active apparatus used for optical amplification and the like at the 1.3-μm wavelength band.

2. Related Background Art

Efforts have been made to manufacture optical devices such as a fiber amplifier, a fiber sensor, and a fiber laser by using a glass doped with a rare-earth element for the application in the fields of optical communications at the 1.3-μm wavelength band and the like. For example, a report has been made (ELECTRONICS LETTERS, 1990, Vol. 26, No. 2, pp. 121–122) in which a neodymium ion (Nd^{3+}) was added to phosphate-based multi-component glass, an optical fiber was formed from this glass, and laser oscillation characteristics of this optical fiber were evaluated. This report shows the characteristics of the optical fiber that a fluorescence peak wavelength was 1.32-μm, an ESA (excited state absorption) peak wavelength was 1.31-μm, and an oscillation peak wavelength was 1.36-μm.

In the multi-component glass indicated in the above report, a sufficiently high laser gain cannot be obtained at the 1.3-μm wavelength band, because the intensity of the fluorescence peak of Nd^{3+} at the 1.32-μm wavelength is relatively weak, and because a relatively high absorption peak caused by ESA transition is present at the wavelength of 1.31-μm.

Further, when optical amplification is performed by utilizing induced or stimulated emission as in the above optical fiber, problems are not only that the fluorescence peak at 1.31-μm wavelength is weak but also that other fluorescence peaks due to possible transition are present. More specifically, in the above optical fiber, in addition to the fact that the fluorescence peak of Nd^{3+} at the 1.3-μm wavelength band is relatively weak the fact that emissions of Nd^{3+} at the 0.8- and 1.06-μm wavelength bands corresponding to other possible transition is relatively strong poses a problem. Due to the induced emission by the light emissions at the 0.8-μm and the 1.06-μm wavelength band, the stimulated emission at the 1.3-μm wavelength band is impeded, and an induced emission efficiency is significantly reduced.

SUMMARY OF THE INVENTION

It is an object of the present invention, to provide an optical functioning glass capable of performing optical amplification at the 1.3-μm wavelength band or near 1.3-μm wavelength band, or improving optical amplification efficiency.

It is another object of the present invention provide an optical fiber and an optical waveguide device, both of which use the above optical functioning glass.

It is still another object of the present invention to provide an optically active apparatus such as an amplifier or a laser, which uses the above optical fiber or the optical waveguide device.

The present inventors have made extensive studies in order to achieve the above objects and have found an optical functioning glass which contains Nd^{3+} as an active ion and which enables optical amplification at about the 1.3-μm wavelength band or increases the amplification efficiency in this wavelength band.

In the optical functioning glass according to present invention, an uranium ion is doped together with an active ion Nd^{3+}. As the host glass (matrix glass) for these dopants, an oxide-based multi-component glass such as a phosphate-based glass, a chalcogenide glass, and the like can be used in addition to a fluoride-based glass. Such an optical functioning glass can be formed by melting a material mixture in which a compound of Nd^{3+} and the uranium ion is added to a glass material.

Since the uranium ion (U^{3+} or U^{4+}) is codoped in the above optical functioning glass, emission of Nd^{3+} in the 1.06-μm wavelength band can be absorbed by the uranium ion. As a result, it is found that a glass suitable for optical amplification at about the 1.3-μm wavelength band can be obtained, as will be described later.

The optical fiber according to the present invention has a core made of the optical functioning glass in which Nd^{3+} is doped as an active ion in the host glass, wherein an uranium ion is codoped in the core and/or the cladding portion. This optical fiber may be formed from, e.g., a core made of the above optical functioning glass, and a cladding layer surrounding the core and having a lower refractive index than that of the core.

In the above optical fiber, since the uranium ion is codoped in the core glass doped with Nd^{3+} and/or a portion of the cladding glass surrounding the core, emission of Nd^{3+} at the 1.06-μm wavelength band can be absorbed by the uranium ion. For this reason, optical amplification of light of the 1.3-μm wavelength band propagating in the core glass can be performed, or the optical amplification gain can be increased. That is, light is effectively confined in the core by fiber formation, and the loss of the confined light is extremely low, thereby forming an inverted distribution in Nd^{3+} with a low threshold value.

Furthermore, the optically active apparatus according to the present invention comprises the optical fiber for propagating light at the 1.3-μm wavelength band and other wavelength bands, a light source for generating light for exciting Nd^{3+}, and optical means for directing the excitation light from the light source to the optical fiber.

According to the above optically active apparatus, Nd^{3+} is excited by, e.g., the excitation light at the 0.8-μm wavelength band directed to the optical fiber by the optical means. Most of the excited Nd^{3+} ions are stimulated by light at about 1.3-μm wavelength incident together with the excitation light in the optical fiber, thereby causing induced emission at about the 1.3-μm wavelength band. Optical functions such as optical amplification, optical switching, and laser oscillation are thus realized at about 1.3-μm wavelength.

In addition, the fiber amplifier according to the present invention comprises the above optically active apparatus and coupling means for coupling the signal light at the 1.3-μm wavelength band or near the 1.3-μm wavelength band to the optical fiber. According this fiber amplifier, large part of the excited Nd^{3+} ion is stimulated by the signal light at about 1.3-μm wavelength directed together with the excitation light in the optical fiber, thereby generating radiation light. Therefore, optical amplification at about 1.3-μm wavelength can be performed.

In addition, the fiber laser according to the present invention comprises the above optically active appara-