Applications of Telecom Light Sources to Non-telecom Fields

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Abstract

NTT Photonics Laboratories has developed advanced design and fabrication techniques to improve the performance of light sources for optical communications and boost the communication capacity. This paper introduces new applications of telecommunications light sources to non-telecommunications fields. These technologies are being commercialized by NTT Electronics Corp. (NEL) based on NTT's Comprehensive Commercialization Functions.

1. Background

Lasers are categorized by their emission sources, which are generally gas (e.g., the argon laser), solid-state crystal (e.g., the Nd:YAG laser), or semiconductor. Semiconductor lasers have become more common because they are small, light, and inexpensive. They are employed mainly in the visible-light and near-infrared regions and have found widespread use in recording media such as CDs and DVDs as well as in the telecommunications field. However, semiconductor lasers have not been available for certain wavelengths such as the 0.5–0.6-μm region (green, lime green, orange) or the 2–5-μm region (mid-infrared). For these regions, other emission sources have been used, but these are more expensive and consume more power than semiconductor lasers. NTT Photonics Laboratories has worked to develop compact lasers that are available for these regions. One device, a wavelength conversion laser [1], combines a highly efficient optical nonlinear crystal and high-output semiconductor lasers designed for telecommunications by using optical device technology for wavelength conversion. Another, a strained-layer InGaAs quantum-well laser emitting beyond 2 μm [2], is the direct result of optimizing the laser design and using novel growth techniques.

Wide-wavelength-band light sources are being applied not only to telecommunications measurement systems but also to an ever-expanding range of fields, including industry and medicine. In particular, they have recently been finding applications in optical coherence tomography (OCT) in the medical field. OCT is a non-invasive *in-vivo* tomography technique that is already being put to practical use in retinal examination equipment, but there is still a demand for improvements to this technique, such as integrating it with an endoscope. These applications require a high-power wideband light source, but conventional semiconductor light sources have not been able to meet the requirements. NTT Photonics Laboratories has also worked to develop a super luminescent diode (SLD) [3] as a compact wideband light source suitable for OCT.

2. New products

The application fields and the bandwidths of these three newly developed light sources are shown in **Fig. 1**. The technical points and features are described in detail in the other selected papers in this issue. Below, we briefly outline the features and applications of these new products.

2.1 Wavelength conversion laser

This laser consists of a highly efficient optical nonlinear lithium niobate ($LiNbO_3$) device and high-power semiconductor lasers. Its output power is 10 mW (30 mW is also available), and it is smaller and consumes less power than a conventional gas laser. It

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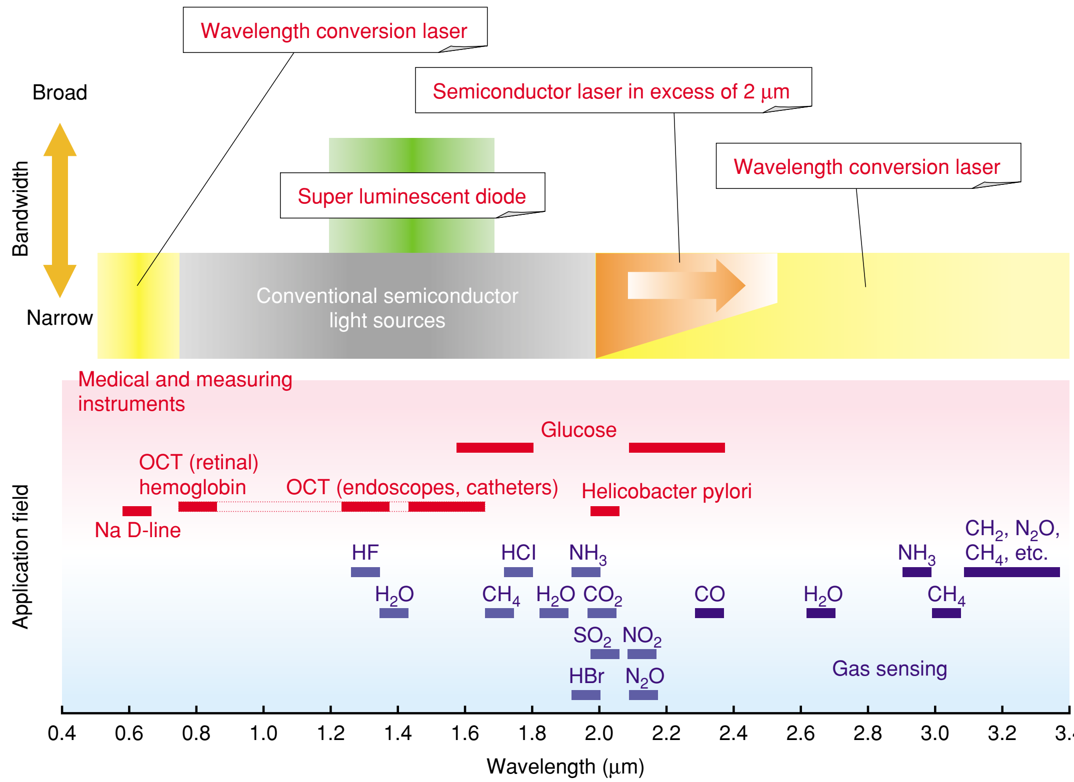

Fig. 1. Application fields and bandwidths of the new light sources.

is easier to maintain than a gas laser because of its long operating life. In addition, an external modulator is unnecessary because direct modulation is possible. Continuous operation at room temperature is possible even in the mid-infrared region of 2 µm or longer. The expected application fields for this product include:

(1) Flow cytometers or confocal scanning laser microscopes, which are used for biotechnological field applications such as cell or DNA analysis
(2) Light sources for environmental gas sensors for carbon dioxide (CO_2), nitrogen oxide (NO_x), sulfur oxide (SO_x), and various other gases
(3) Light sources to replace sodium (D-line) lamps used to analyze the constituents of medical products, food, and chemicals.

2.2 Super luminescent diode (SLD)

The central emission wavelength of this product is in the 1.3-µm infrared region. In this wavelength region, water and hemoglobin both exhibit little absorption and the light is less susceptible to scattering, so living tissue exhibits the greatest transparency at this wavelength. Consequently, the light produced by this product can penetrate deep into the body from the surface of the skin.

Our SLD can achieve a spatial output of at least 50 mW and a single-mode fiber-coupled output of at least 30 mW, so it dispels the conventional idea that SLD light sources have low optical output. Due to the trade-off between bandwidth and optical output, there have never before been any SLDs that combine a large optical output with a wide bandwidth. However, by optimizing the active layer structure of our SLD device, which is the core region where light emission takes place, we have managed to achieve a large bandwidth of at least 50 nm even when operating with a large spatial output power of 50 mW or more. The expected application fields for this product are:

(1) Optical coherence tomography in the medical field
(2) Molecule or gas sensing systems
(3) Evaluation and measurement of optical components such as optical time domain reflectometers (OTDRs).

2.3 Strained-layer InGaAs quantum-well laser emitting beyond 2 µm

This laser emits light with wavelengths of 2.0–2.1 µm. In this wavelength region, light is strongly absorbed by CO_x, NO_x, and glucose, which are important substances in the medical and environmental fields. Although light absorption by these substances can also be detected at communication wavelengths, the intensity is weak and detection is difficult. This newly developed laser emission source is much more sensitive to these substances. For example, a 100-fold improvement in sensitivity has been achieved for CO_x compared with the use of the communication wavelength band. This allows realtime monitoring of CO_x or other substances.

Until now, solid-state lasers have been the main source light for a wavelength of 2.0 µm. These lasers have several drawbacks such as large equipment configurations and a high price. NTT's new product eliminates these shortcomings by radically reducing the laser body size to 1/100 and lowering the unit price by 80%. In addition, direct modulation of the optical output intensity is possible, and the simplified equipment configuration will allow us to develop portable devices in the near future. This product is more compact and simpler than the wavelength conversion laser. The expected application fields for this product are:

(1) Sensors for helicobacter pylori and blood glucose in the medical field
(2) Monitoring and exhaust control systems for CO_x/NO_x in the environmental field.

3. Conclusion

NTT Photonics Laboratories has developed advanced design and fabrication techniques for semiconductor laser light sources for optical communications. These technologies have led to new light sources for non-telecommunications fields. The commercialization of these technologies by NTT Electronics Corp. (NEL) is based on NTT's Comprehensive Commercialization Functions. It is hoped that this policy, which has been in effect since July 2003, will continue to promote the widespread commercialization of various R&D achievements in the future.

References

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[2] http://www.ntt.co.jp/news/news05e/0503/050302.html
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