NTT
NIPPON TELEGRAPH AND TELEPHONE CORPORATION

# NEWS RELEASE

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## NTT has developed innovative light sources for cost-reduced optical transmission system

- 1.55 μm vertical-cavity surface-emitting lasers operating with extremely low threshold current (1/100 compared to conventional lasers) -

Nippon Telegraph and Telephone Corporation (NTT) has developed 1.55 μm vertical-cavity surface-emitting lasers (VCSELs) which exhibit room-temperature continuous-wave (RT-CW) operation with the lowest threshold current in the world and entirely with fundamental transverse mode.
The VCSELs are receving much attention as high-performance and low-cost light sources. Especially 1.55 μm VCSELs are desired because the transmission loss of optical fibers is minimum at the wavelength, however their chracteristics have not reached sufficient level: the threshold current has been higher than 1 mA, and the emitting wavelength and beam spot has not been single.
This time, we have proposed the new VCSEL structure so that the driving current can be remarkably reduced, and have successfully demonstrated the lowest threshold current RT-CW operation with single emission wavelength and fundamental transverse mode, which is essentially required for long-distance optical fiber transmission (Fig.1).
The key to realize such operation is that we have developed "Thin Film Wafer Fusion Process," by which InP-based semiconductor-buried emitting structure can be fused to GaAs-based mirror.
When 1.55 μm VCSELs are practical, we expect to reduce the consumption power of laser sources in optical trasmission system by 1/100, and also their cost compared to conventional edge-emitting lasers. We have a plan to brush up their performances and reliability.

**Background of the development**
In optical transmission system, semiconductor laser diodes (LDs) have widely used. Conventional LDs are "edge-emitting" type, in which light is emitted from the cleaved wafer surface parallel to the waveguide processed on semiconductor wafer. On the other hand, in VCSELs, light is emitted from semiconductor surface. They have been paid attentions because they can be operated with extremely low current (1/100 of the value for edge-emitting LDs) and give high-performance such as low voltage and high frequency modulation with low cost. 0.85 μm GaAs-based VCSELs have already commercialized from a lot of manufacturer in the world in order to apply to high-bit-rate optical local area network (LAN) such as Gigabit Ethernet and Fiber Channels. However, for 0.85 μm VCSELs, the transmission distance is limited up to several hundred km, so 1.55 μm or 1.3 μm VCSELs are desired to extend the distance to longer than 1 km. In these wavelength VCSELs, it is difficult to use the same semiconductor material for active region and mirror, which are main components of VCSELs. Variable device structures have been proposed to overcome such technical difficulties, however their threshold current has been more than 1 mA and single emission wavelength and fundamental transverse mode operation has not yet been

obtained.

**Technical key point**
Our developed VCSEL structure has two remerakble features. The first one is that InP-based active region is combined with GaAs-based mirror by using our original "Thin Film Wafer Fusion" process (Fig. 2). GaAs-based mirror has more than 99 % of reflectivity and good thermal conductivity. InP-based active region is reliable and the emission wavelength is precisely determined. The second feature is that the InP active region is buried with another semi-insulating InP layer. The curent is effectively injected into the active region without any leakage. Furthermore the generated light is effectively confined within the active region, so it is emitted with low loss.
Due to the introduction of above two technology, we have successfully demonstrated RT-CW operation 1.55 μm VCSEL with the lowest threshold current (0.38 mA) in the world. The wavelength spectrum had only one peak, and laser beam was single spot (Fig.3). These results indicate that the VCSEL can be applied to long-distance optical transmission with single-mode fibers.

**Application field**
We have accomplished a significant milestone toward achieving the practical level of 1.55 μm VCSELs. The devices will be applied as high-performance and low-cost light sources of more extended optical MAN and WAN. Optical interconnection between board and board in computers are other possible application because the VCSELs have very low power consumption. Furthermore multiwavelength array of 1.55 μm VCSELs will be introduced to WDM network. As above mentioned, 1.55 μm VCSEL will be a key component in future photonic network.

**Abbreviation**
VCSEL : Vertical Cavity Surface Emitting Laser
LAN : Local Area Network
MAN : Metropolitan Area Network
WAN : Wide Area Network
WDM : Wavelength Division Multiplexing

**Technical Terms**
**Fundamental transverse mode operation**
The operation that laser oscillation mode perpendicular to optical beam is single. The beam intensity profile has a peak at the center, so the coupling to optical fiber becomes effective.

**Thin film wafer fusion process**
The process that the semiconductor films with the substrate is fused to another semiconductor wafers after completely removing the former substrate. By thanks to the process, InP- and GaAs-based epitaxial films can be conbined keeping their high-qualities after they are independently grown their original substrate.

**Vertical-cavity surface-emitting laser**
The laser where light-generated active layers and mirror layers are stacked perpendicular to semiconductor wafer surface. The light is emitted from the wafer surface. It has a lot of advantages, so it is expected to be a key component in future

optical transmission system.

**Edge-emitting laser**
The laser where the stripe of active region and the mirrors are processed parallel to semiconductor wafer surface. It is commonly used in optical transmission system now.

- Fig.1 Innovative light sources for optical transmission
- Fig.2 Cross-sectional view of 1.55μm VCSEL
- Fig.3 Characteristics of 1.55μm VCSEL

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