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NTT Advanced Technology Corporation

Hamamatsu Photonics K.K.

New Medical Light Source using NTT's Communication Laser Technology

- NTT-AT and Hamamatsu Photonics K.K. to sell the highest -speed wavelength swept light source that reduces the impact of diagnostic imaging on patients -

In a joint partnership, NTT Advance Technology Corp. (hereinafter: NTT-AT; head office: Shinjuku-ku, Tokyo; President and CEO: Takashi Hanazawa) and Hamamatsu Photonics K.K. (head office: Hamamatsu-shi, Shizuoka; President and CEO: Akira Hiruma) will start selling a 1.3-μm-band wavelength swept light source for use in optical coherence tomography (OCT) on February 1. OCT is a non-invasive in vivo imaging technique that is widely used in clinical applications.

NTT-AT has developed this product using the same technology employed in the manufacture of an electro-optic crystal called KTN (potassium tantalate niobate: $KTa_{1-x}Nb_xO_3$) developed for use in telecommunications by Nippon Telegraph and Telephone Corporation (hereinafter: NTT; head office: Chiyoda-ku, Tokyo; President and CEO: Hiroo Unoura). The product is a marriage between this technology and high-speed variable wavelength laser technology that uses the crystal. Achieving a wavelength sweep speed of 200 kHz, the world's fastest (double that of conventional products), this light source will speed up OCT-based examinations, significantly reducing the physical impact on patients. NTT-AT manufactures this product and will market it jointly with Hamamatsu Photonics K.K., a company which has significant involvement in the manufacture and sale of medical devices and has a global sales network. The two companies will work together in selling wavelength swept light sources for OCT, and undertake joint development in order to augment their product portfolios and facilitate mass production, thereby expanding their presence in the medical device market.

This light source will be on display in the booths of the two companies at the exhibition that will be held in conjunction with SPIE Photonics West 2013 in San Francisco from February 2 to 7.

1. Overview of the product and background

[Current state of OCT technology]

OCT captures a cross-sectional image of a living body by irradiating it with a laser beam and detecting the light that is reflected by internal organs. Unlike computerized tomography (CT), which uses an X-ray, OCT does not allow observation of deeper regions of a body. However, it makes it possible to observe tissues several millimeters deep at ultrahigh resolution. Specifically, it can obtain cross-sectional images of these tissues with a resolution of several to several tens of micrometers. A diagnostic imaging technology developed in 1991, OCT is today widely employed by universities and other research institutes, flagship hospitals, and even clinics. Initially developed to take advantage of this high resolution to examine the fundus of the eye, OCT was later incorporated into imaging devices used to examine the retina. In recent years, it has been used in combination with a catheter to examine the coronary arteries, a technique recognized as an innovative way to gauge the degree of blood vessel occlusion.

While there are several types of OCTs, swept source OCT (SS-OCT) [*1], which uses a laser with sweeping wavelength at high speed, is almost certain to become the most widely used because of its ability to obtain high-resolution images at high speed. By selecting a laser that emits the most appropriate wavelength for the specific organ to be examined, OCT can be used to examine various organs in a human body, such as the eye (e.g., anterior eye and retina), digestive organs (e.g., esophagus and stomach), and circulatory organs (e.g., coronary arteries). The image taking time for this type of OCT depends on the wavelength sweep speed of the light source. The faster the wavelength sweeps the shorter the image taking time. Existing wavelength swept light sources available on the market continuously change the wavelength by moving a mirror at high speed. Such a mechanical scheme has a limitation in terms of the driving speed, being unable to exceed 100 kHz. The primary objective of OCT instrument manufacturers has been to develop a high-speed wavelength swept light source in order to significantly shorten examination duration, thereby reducing the impact on patients. High-speed wavelength swept light sources that can run at a speed higher than 200 kHz using optical fiber technology already exist, as well as technology that combines a micro-electro-mechanical system (MEMS) and a semiconductor laser. However, these are expensive and bulky.

[Features of this product]

The newly developed light source **(Fig. 1)** uses a high-speed KTN light deflector[*2] **(Fig. 2)** and high-speed wavelength swept variable laser technology, both developed by NTT for used in telecommunications. This is currently the fastest commercial product in the world. The wavelength used is in the 1.3 μm band, the band used for OCT-based examination of the coronary arteries. In addition to the high-speed sweep at 200 kHz, the product has the following performance features: wavelength sweep span larger than 100 nm, average light output of 15 mW, and coherence length longer than 7 mm. OCT systems that incorporate this product can take high-resolution cross-sectional images of living tissue at high speed. This feature will not only reduce the time required to complete an examination but also broaden the application of OCT systems, such as innovative medical diagnosis using real-time 3D imaging, and clinical study applications in the field of R&D.

Fig. 1 Newly developed wavelength swept light source for OCT

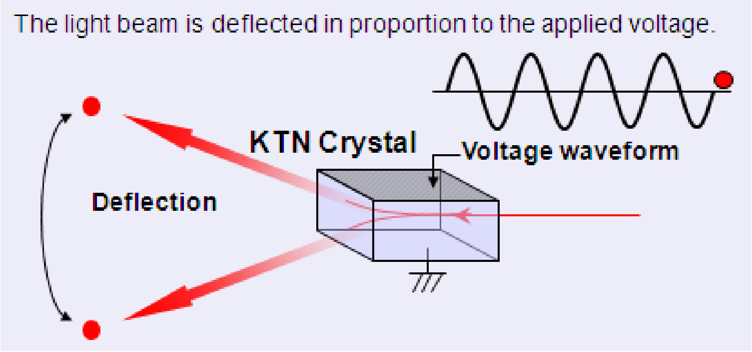

Fig. 2 High-speed light deflector

[Technical points]

(1) High-speed lightwave sweep enabling high-speed, high-resolution imaging (Fig. 3)

The maximum wavelength sweep speed that can be achieved with conventional products is 100 kHz. These products use a MEMS mirror as the light source to achieve a high-speed sweep. However, a MEMS mirror has a moving part, which limits the maximum speed to below 100 kHz. The high-speed KTN light deflector (Fig. 2) used in the newly developed product has no moving parts. It deflects light using an electro-optic effect[*3]. This can dramatically increase the operating speed of the product (See NTT Press Release on May 18, 2005). The new product operates at 200 kHz, double the speed of conventional products. This allows instantaneous imaging taking, thereby reducing examination time. This also means that twice as many images can be taken per unit time. Therefore, a large number of images can be rapidly acquired to produce high-resolution images with reduced noise. This high-speed operation also makes it possible to take high-resolution images with 4000 voxels at a rate of 50 fps, allowing an OCT system using this light source to produce a high-resolution 3D image of a living body.

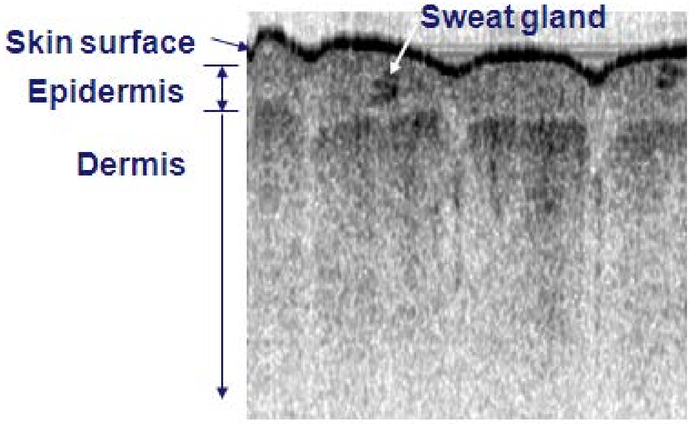

Fig. 3 OCT image taken by this product of upper layers of the skin (finger)

(2) High-performance wavelength swept light source using a KTN light deflector

The newly developed wavelength swept light source uses a laser with an external resonator, the so-called Littman-Metcalf configuration. The laser includes a highly efficient diffraction grating and KTN light deflectors. This compact and optimized structure has made it possible to achieve high-speed operation, a wide wavelength sweep span, and sufficient coherence length **(Fig. 4)**.

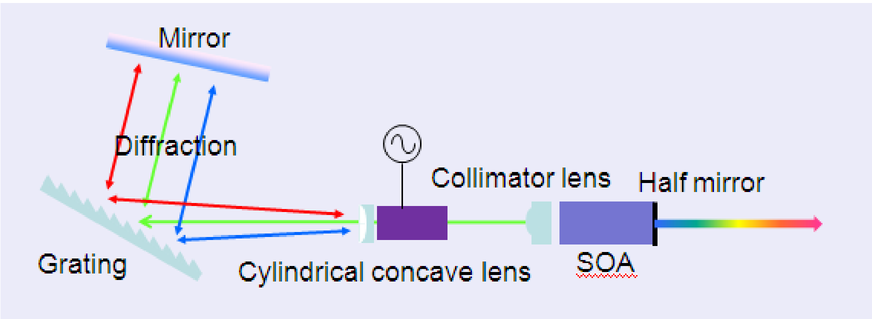

Fig. 4 Structure of the wavelength swept light source

2. Collaboration between NTT-AT and Hamamatsu Photonics

NTT-AT has made use of communication laser technology developed by NTT to develop a commercial medical laser light source. Hamamatsu Photonics, on the other hand, has for many years held a sizable share, both in Japan and abroad, of the market for medical applications of optical semiconductors and optical detectors, and boasts a strong global sales network in addition to developing and manufacturing related products. With NTT-AT aiming to apply communication device technology to the medical field, and Hamamatsu Photonics being experienced in the development, manufacture, and sale of medical products, the two companies have decided to collaborate to broaden their business opportunities globally. They will also work together to combine NTT's R&D results with Hamamatsu Photonics' outstanding optical semiconductor technology in order to enhance performance of the wavelength swept light source, expand the wavelength range in which the light source can operate, and to develop mass production technology. Through this collaboration, the two companies aim to broaden the scope of their respective businesses, including in the medical area, and thereby contribute to society.

3. Future activities

This product is designed for sale as a stationary light source to be incorporated in OCT systems for development purposes. The goals of the combined efforts of the two companies over the next year include development of a light source in the 1.05-μm band, which is being increasingly used in OCT examination of the fundus, expansion of their product portfolios, and enhancement of the performance of the light source. The companies also aim to develop a high-speed optical detector that will allow high-quality images to be taken, and products that combine their light source with a 2D sweep mirror.

<Glossary>

*1: Swept Source Optical Coherence Tomography (SS-OCT)

Two OCT systems are currently attracting interest: SD-OCT (spectral-domain OCT) and SS-OCT (swept-source OCT). A feature of SD-OCT is that its signal detector is a spectroscope while SS-OCT's light source is a wavelength swept coherent light. In particular, SS-OCT has grabbed the limelight because image taking can be sped up by increasing the wavelength sweep speed. An OCT system constructs a 2D cross-sectional image by sweeping the wavelength of the light source to capture images in the depth direction (A-line scan) and sliding the laser beam horizontally (B-line scan). With SS-OCT, one image in the depth direction (A-line) can be taken by scanning a single wavelength. Therefore, the time needed to take an OCT image depends on the wavelength sweep speed.

*2: KTN light deflector (Fig. 2)

A light deflector is also called an optical scanner. When the refractive index distribution of a KTN crystal, which is an electro-optic crystal, is varied by the superposition of the space charge injected inside the crystal and the external electrical field, the light transmitted to the crystal is deflected. This mechanism allows high-speed operation of 200 kHz (double the speed of conventional products) or higher. Since a KTN crystal can respond to an electrical field of hundreds of MHz, it will be possible to develop a light deflector that operates at several MHz.

*3: Electro-optic effect

This is a phenomenon in which the refractive index varies with the applied voltage. There are two types of effect: Pockels effect, in which the refractive index is proportional to the voltage applied, and the Kerr effect, in which the refractive index is proportional to the square of the voltage applied. KTN crystals exhibit the Kerr effect.

[Product overview]

- Main specifications

Item	Specification
Wavelength sweep speed	200 kHz
Central wavelength	1320±10 nm
Wavelength sweep span	> 100 nm
Average output	17mW
Coherence length	> 7 mm
Dimensions	250 mm(W) ×300 mm(D) × 150 mm(H)

- Sale date: February 1, 2013
- Regions of sale: Many parts of the world, including Japan, Europe and the United States
- Price in Japan (after tax): 2,830,000 yen
- Sales target: The annual sales target after 3 years is 0.5 billion yen with 30% market share.

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