

TYDEX: OPTICS FOR THz PHOTONICS

TYDEX offers a wide range of optics for THz photonics: passive components (lenses, windows, prisms, mirrors, spectral and beam splitters, and waveplates), built up components (low pass and band pass filters, polarizers, and attenuators), and devices (Golay detectors).

Keywords: AR coating, THz lenses, THz windows, THz prisms, THz mirrors, THz spectral and beam splitters, THz waveplates, THz low pass and band pass filters, THz polarizers, THz attenuators, Golay detectors.

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ТИДЕКС: ОПТИКА ДЛЯ ТГц ФОТОНИКИ

ТИДЕКС предлагает широкий диапазон оптики для ТГц фотоники: пассивные компоненты (линзы, окна, призмы, зеркала, светоделители, спектральные делители, волновые пластинки), сборные компоненты (фильтры нижних частот, полосовые резонансные фильтры, поляризаторы, аттенюаторы) и устройства (детекторы Голя).

Ключевые слова: просветляющие покрытия, ТГц линзы, ТГц окна, ТГц призмы, ТГц зеркала, ТГц лучеделители, ТГц спектральные делители, ТГц волновые пластинки, ТГц фильтры нижних частот, ТГц полосовые резонансные фильтры, ТГц поляризаторы, ТГц аттенюаторы, детекторы Голя.

Introduction

Nowadays interest to THz radiation is growing fast. Many different disciplines such as ultra fast spectroscopy, semiconductor device fabrication, and bio-medical imaging involve the recent development of THz technology. The THz research activities have mainly focused on generation and detection until lately, but the focal point has shifted to the practical applications such as high-speed communication, molecular spectroscopy, security imaging, and medical diagnosis, among many others [1].

Research and industrial applications require availability of good tool base. To satisfy needs of THz photonics TYDEX develops and produces a wide range of optics. Offered products can be divided into three groups:

- Passive components (lenses, windows, prisms, mirrors, spectral and beam splitters, and waveplates);
- Built up components (low pass and band pass filters, polarizers, and attenuators);
- Devices (Golay Detectors).

Crystalline materials (high-resistivity float zone silicon (HRFZ-Si), crystal quartz and sapphire) as well as polymer ones (polymethylpentene (TPX) and high-density polyethylene (HDPE)) are used for components manufacturing. Organic materials have uniform stable transmission about 80-90% starting from ~200 μm and to 1000 μm and more. It should be noted that TPX is optically transparent in UV, visible, and THz ranges, what allows using a HeNe laser beam for alignment. Crystalline materials have lower transmission in THz range due to reflection losses. For silicon it is 50-54% starting from 50 μm , for quartz it is >70% starting from about 120 μm , for sapphire it is >50% starting from about 350 μm at 1-2 mm sample thickness.

1. Passive components

TYDEX offers lenses of different shapes. Meniscus, hyper-/hypo-/hemispherical, bullet, and plano-cylindrical lenses are made of HRFZ-Si and plano-convex and bi-convex

lenses – of TPX. AR coating of hemispherical HRFZ-Si lenses is possible. One-sided (spherical surface) AR coating increases transmission of the lens by 30 relative percents in comparison with transmission of uncoated lens in specified range.

Windows (plano-plano and wedged) are produced of any material mentioned above. AR coating of HRFZ-Si windows is offered. Transmission of two-sided AR coated window is increased up to 90 % in specified range.

TYDEX manufactures HRFZ-Si prisms of the following configurations: right angle and attenuated total reflectance (ATR) ones. Right angle prisms are used in optical schemes. ATR prisms allow investigating materials which are difficult to analyze in transmission.

Also TYDEX produces NIR- and MIR-THz spectral splitters (HRFZ-Si and crystal quartz substrates). NIR-THz splitter is used for separation of pump radiation (center wavelength is 790–800 nm) from THz radiation in Ti:Sapphire laser and MIR-THz splitter – for separation of pump radiation (9.6 μm and 10.6 μm) from THz radiation in THz laser optically pumped by CO₂-laser.

There are two types of HRFZ-Si beam splitter we supply. The first one is singlepass beam splitter with transmission/reflection ratio ~54%/46%. It is used in optical schemes where radiation passes through beam splitter one time. In fact, plano-plano HRFZ-Si window could be used as singlepass beam splitter. The second

type of beam splitter is used in Michelson interferometer scheme where beam passes through splitter several times. Beam splitter for Michelson interferometer as opposed to conventional beam splitter is produced with very high degree of accuracy.

Gold coated mirrors (quartz glass substrate) for full reflection of THz beam are offered too.

TYDEX supplies monochromatic $\lambda/2$ and $\lambda/4$ crystal quartz waveplates for different operating wavelengths in the range of 35 to 1000 μm .

2. Built up components

Besides passive THz components TYDEX manufactures low pass and band pass filters, polarizers and attenuators.

THz low pass filters are intended to block short wavelengths and transmit THz radiation from MIR to MM. Standard cutting wavelengths are the following: 13 μm , 21 μm , 27.5 μm , 34 μm , 55 μm , 70 μm , 75 μm , and 94 μm . The filter is a set of materials mounted in a holder with a fit ring. Action principle of the filter is based on redistribution of radiation by means of dispersion, reflection, scattering, diffusion, diffraction, and interference. These filters have high transmittance (up to 95%) in pass range and low transmittance (<0.1%) in suppression range. Example of transmission spectrum of low pass filter is shown below.

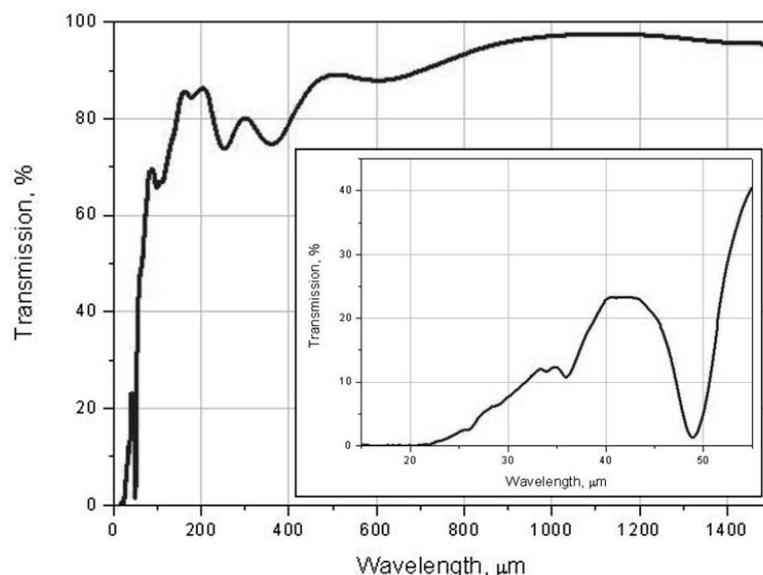


Fig. 1. Transmission spectrum of low pass filter with blocking wavelength 21 μm

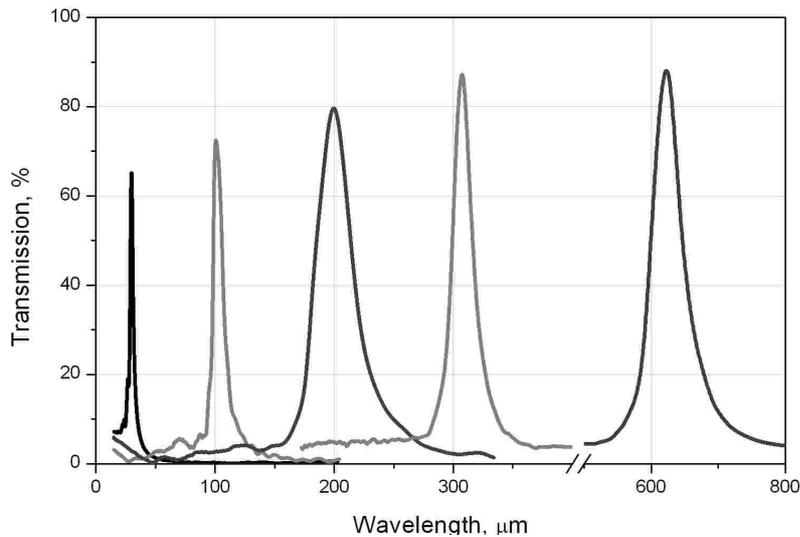


Fig. 2. Transmission spectra of band pass filters with central wavelengths 30 μm, 100 μm, 200 μm, 305 μm and 620 μm

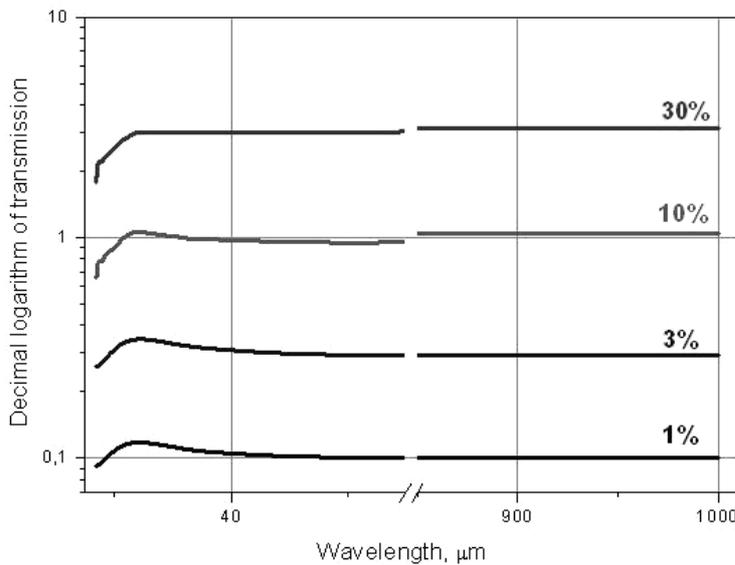


Fig. 3. Transmission spectra of THz attenuator elements

THz band pass filters are intended to transmit the wavelengths in the range of 20 μm to 1000 μm. The filters are fabricated from thin metal foil with holes. Required central wavelength is defined by geometry of the holes and can be any in above mentioned range. These filters settle the problems of quasi-optical filtration of radiation in THz range. They also permit to get high degree of monochromatization while aperture ration of device is also high. It is worth using band pass filters when it is important to have high spectral resolution with high aperture ratio as well as small overall dimensions and weight of device. Transmission of such filters at maximum is 65-90% and transmission at suppression range is <4%. Trans-

mission spectra of five band pass filters are shown below. The filters are supplied in holders.

To polarize radiation from 7 μm to MM waves TYDEX offers polyethylene polarizers. They are the sort of diffraction gratings. The polarizer grating is made by forming grooves of a triangle profile on the substrate (HDPE) and subsequent deposition of a metal coating (aluminum) on one of the groove facets. The polarizers are supplied in holders (protective ring with marked grid direction).

Variable wheel accessory is used for attenuation of high-power THz radiation (40 μm ÷ >1000 μm). It consists of 5 wheels. Four wheels contain wedged metalized silicon wa-

fers with different attenuation levels and one wheel is empty. If necessary empty wheel can be filled with custom element (e.g. filter). The four attenuators have transmission 30%, 10%, 3%, and 1%. Their transmission curves (noise is smoothed) are shown below. These attenuator elements can be used as single attenuators or in combination that allows achieving different levels of attenuation (from 30% to 0.001%).

3. Devices

Also TYDEX supplies one of the most efficient detecting devices - Golay Cell. It has excellent sensitivity at room temperature and flat optical response over a wide wavelength range.

Three models of Golay Cells are available:

- GC-1P - Golay Detector with HDPE window is intended for monitoring and control of MIR and THz radiation;

- GC-1T - Golay Detector with TPX window – for operating with UV-NIR and THz radiation;

- GC-1D - Golay Detector with Diamond window – for usage of VIS-THz radiation.

Golay detectors are manufactured in-house and calibrated individually. Delivery includes a detector head and a power supply unit. A mount for the filters and low pass filters can be supplied as an option.

Other THz built up components and devices are in progress.

References

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15.09.2010