9-1 INVITED: Design and Performance of Acousto-Optic Light Deflectors

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Among various types of light beam deflectors, acousto-optic light deflection is one of the promising techniques because of the following advantages: 1) capability of rather high capacity, 2) ease in control of deflection modes and position, 3) simple structure of deflector element, and 4) wide variety of usage from a single deflector. These advantages make the acousto-optic deflector useful for applications to several optical systems such as holographic memory, laser display, printer, facsimile, and laser machining.

Development of acousto-optic devices has been supported by the discovery of several superior acousto-optic materials and the improvement in design and fabrication technology of device element.

Search and selection of suitable materials started in the latter half of 1960's from the practical viewpoint, and several materials that are good for the devices have been successively found. These materials include $LiNbO_3$, GaP, α-HIO_3, $PbMoO_4$, TeO_2, Pb_2MoO_5, $Pb_5(GeO_4)(VO_4)_2$, Ge, a group of chalcogenide glasses, and tellurite glass. The interaction medium used for the deflection element presents the problem of size most urgently because of the inescapable use of a large-aperture laser beam. Thus, the availability of large size element with high optical quality is one of the most important factors to construct the practical deflector.

Improvement of high frequency acoustic technology and new proposals such as acoustic beam steering and the use of the abnormal Bragg reflection phenomenon are the other motive forces in the development of acousto-optic light deflectors. Efficient launching of the high-frequency acoustic beam into interaction medium is required for the fabrication of excellent deflector with large number of deflection spots. The bulk-type acoustic transducer bonded onto the medium by ultrasonic welding technique and thinned by the sputter etching seems to be the most suitable for this purpose at present. For high-frequency and wide-band deflector, the use of the acoustic beam steering techniques are unavoidable in order to preserve the Bragg angle by varying the acoustic frequency at a constant angle of the incident light beam. The abnormal Bragg reflection is also successfully utilized for the construction of the large-capacity deflector.

The usefulness of the acousto-optic deflector may be considerably increased if the three basic requirements, i.e., high efficiency, large capacity, and high speed, are all realized in one and the same deflector. However, in the present state of the art, any two of the above three requirements can be easily satisfied at the same time, but it is hardly possible to satisfy all three. For example, high efficiency and large capacity are satisfied in dense flint glass deflector and TeO_2 [110] shear type one. This type of deflector is very close to practical application in laser display, printer, and facsimile systems. In the category of highly efficient and high-speed deflectors, we have $PbMoO_4$ and TeO_2 longitudinal-type ones which have been utilized for the readout means in the experimental holographic memory systems. In order to attain further development in the optical memory system, deflectors having a capacity larger than 1000 spots in one dimension must be fabricated without any loss of efficiency and access time.

As examples of fabrication and performance of the acousto-optic deflector, we describe recent advance in the two kinds of TeO_2 deflectors achieved in our laboratory. In the first type, we used the longitudinal wave propagating along the c axis with the center frequency around 150MHz. A 36°Y-cut $LiNbO_3$ transducer was ultrasonically bonded using deposited In film of 0.5μm in thickness. The 1.5dB bandwidth of diffracted light intensity was 60MHz, and the number of resolvable spots was 120 for 2μsec access time and 300 for 5μsec access time. The efficiency was 80% in CW operation and 95% in pulsed operation. In order to attain such high efficiency, careful construction of acoustic absorber and heat sink was required. In the second type of TeO_2 deflector, we used exceptionally slow shear wave propagating along the [110] direction. An X-cut $LiNbO_3$ transducer array with 2-4 elements has been fabricated by deposition of divided bonding and electrode layers. Mechanical impedance of TeO_2 for this shear mode is only 0.166 time as large as that of the transducer, and the use of the intermediate layer with appropriate mechanical impedance and thickness is necessary for achieving the wide band operation. Frequency dependence of diffracted light intensity is shown in Fig. 1. By using In layer of 3.6μm thick, we obtained the maximum diffraction efficiency of 85% and the bandwidth of more than 30MHz.

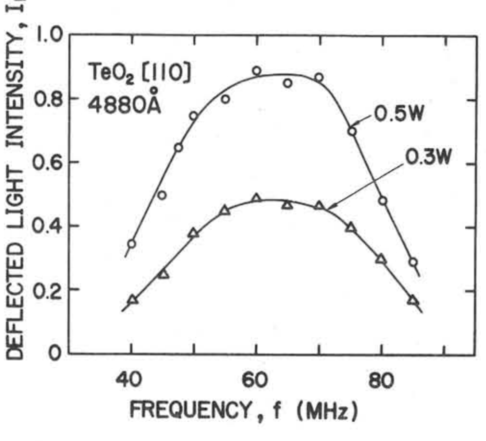

Fig.1