CLM-P 395

OBSERVATION OF WEDGE FRINGES ON CO_2 LASER OPTICAL COMPONENTS

by

V.I. Little*, A.C. Selden+ and T. Stamatakis+

(Submitted for publication in J. Phys. E, Sci. Instrum.)

ABSTRACT

During the operation of a high power pulsed CO_2 laser system, damage was observed to a GaAs modulator crystal. The cause of the damage was the creation of wedge fringes within the crystal. Wedge fringes were also formed in the system by a Ge polarizing plate. This note describes how the formation of such fringes can be avoided and also how they can be used to measure small wedge angles over long path differences.

* Royal Holloway College, University of London

+ On attachment from Royal Holloway College, University of London

UKAEA Research Group,
Culham Laboratory,
Abingdon,
Berks.

June 1974

Since damaged components in a laser system limit the performance of high-power lasers, it is of critical concern to make the optical element of the laser less susceptible to such damage.

The use of optical components made of material with a high refractive index - like Ge or GaAs - as beam splitters, windows, polarizers and electro-optical modulators of the laser beam usually results in the formation of undesirable fringes which are, very often, the reason for the damage of those components themselves or which lead to the damage of other components in the optical system.

Usually these fringes are of equal thickness (straight-line wedge-fringes) which occur when the two surfaces of the component are inclined. Generally in such components the locus of the points of equal thickness, which represents the edge of the wedge, forms an angle with the geometrical edge of the component i.e. a rectangular plate. As a result of this, the fringes which are produced on transmission or reflection appear to rotate when the angle of incidence is changedi.e. the angle between the plane of incidence and the straight-line fringes appears to change (Fig. 1a).

Using these fringes the generally very small angle ϕ of the inclined surfaces can be calculated by measuring the fringe spacing d.

For normal incidence ϕ is given by

$$\phi = \frac{\lambda}{2nd} \qquad (1)$$

(where λ is the wavelength and n the refractive index).

Recently this method was used (McLeod 1974) to check the parallelism of glass blocks with a He-Ne laser.

In a TEA CO_2 10.6 μm laser system for producing short laser pulses by electro-optical means, a germanium plate was used to produce linearly polarized light by reflection. This light was then incident upon a gallium arsenide crystal.

However, both the Ge plate and the GaAs crystal produced wedge fringes which caused surface damage to the 5 cm long crystal. The exit surface of the crystal was damaged whilst the entrance surface suffered no damage. It has been proposed that this is due to the effect of Fresnel reflection (Crisp et al 1972). In the case of GaAs, which has refractive index $n = 3.3$, the light intensity inside the GaAs at the exit surface is $4n^2/(n + 1)^2 = 2.35$ times greater than the intensity inside the GaAs at the entrance surface.

In order to avoid the fringes produced by the Ge plate, its back surface was given a matt finish using wet emery cloth. Consequently, the fringes disappeared as is shown in Fig. 1b, and a uniform beam of linearly polarized light was reflected from the plate.

The fringes which are produced by the crystal can be excluded by applying a bias d.c. voltage. With increasing voltage the fringes gradually diminish. When the applied d.c. voltage equals the quarter-wave value the fringes almost disappear (Fig. 1c). Consequently the disappearance of the fringes can be used to measure the quarter-wave voltage and the electro-optic coefficient r_{41} of the GaAs.

The inclination of the two faces of the GaAs crystal was found from equation (1) using the observed fringe spacing d, and the known values of refractive index n and wavelength λ. This agreed within 4% with the values deduced from the displacement of the reflected and transmitted beams caused by refraction in the wedge.

This is a valuable method of measuring small wedge angles on infra-red components over relatively long path differences - 5 cm in the present case.

References

Crisp M.D., Boling N.L. Dube G. 1972 Applied Physics Letters, Vol 21 No 8 364-6.

McLeod J. 1974 Optics and Laser Technology Vol 6 No 2 57-60.

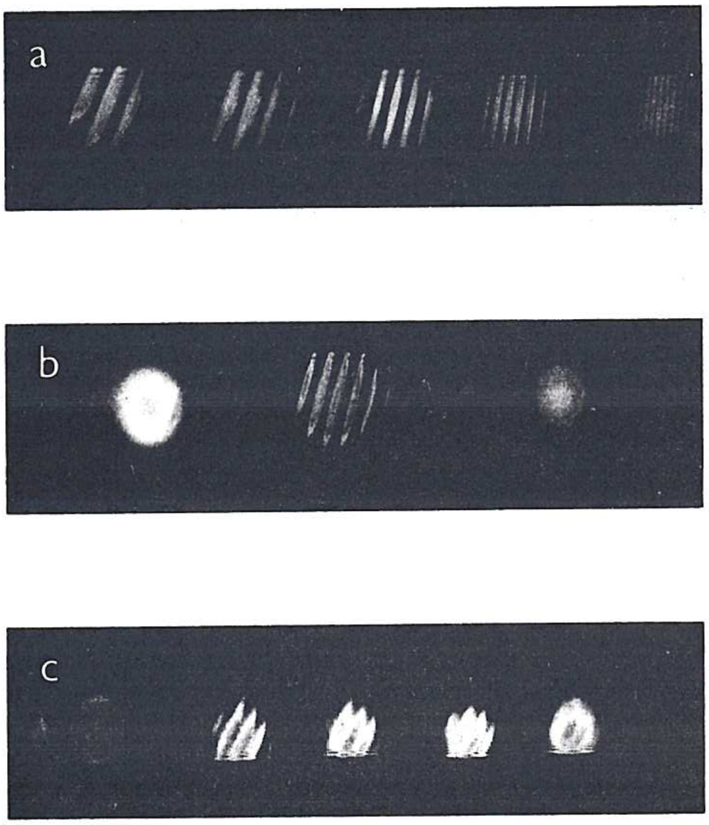

Fig. 1 Wedge fringes on CO_2 laser components.

a. Rotation of fringes with varying angle of incidence.

b. Effect of back surface finish of germanium plate on fringe visibility - from left to right: incident beam, reflected fringes (Both faces polished), and smooth reflected beam with matt back surface.

c. Effect of applied voltage on fringes produced in GaAs electro-optic crystal - voltage increasing left to right from zero to quarter-wave value (12 kV/cm). Incident beam on far left.

CLM-P395