

- [54] **DEVICE FOR PRODUCING STIMULATED INFRARED EMISSION, AN IRASER, HAVING A WAVELENGTH OF APPROXIMATELY 10.6μ BY MEANS OF AN ELECTRIC DISCHARGE IN A GAS MIXTURE CONSISTING PARTLY OF CARBONIC ACID GAS, AND ELECTRIC DISCHARGE TUBE DESTINED FOR SUCH A DEVICE**

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- [22] **Filed:** Nov. 7, 1972

- [21] **Appl. No.:** 304,394

Related U.S. Application Data

- [63] Continuation of Ser. No. 151,957, June 10, 1971, abandoned, which is a continuation of Ser. No. 821,417, May 2, 1969, abandoned.

- [30] **Foreign Application Priority Data**

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- [52] **U.S. Cl.** 331/94.5, 330/4.3

- [51] **Int. Cl.** H01s 3/22

- [58] **Field of Search** 331/94.5; 330/4.3

- [56] **References Cited**

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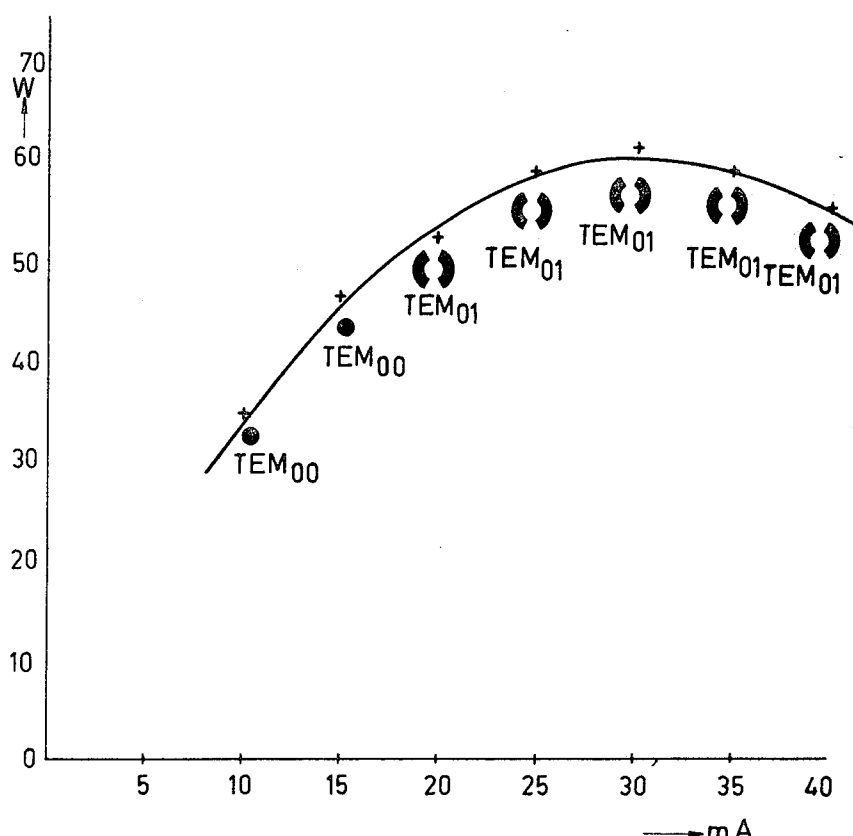
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ABSTRACT

According to the invention, a device is provided for producing stimulated infrared emission, an iraser, having a wavelength of approximately 10.6 by means of an electric discharge having a current density exceeding 15 m⁴/sq.cm in a gas mixture. The mixture consists of carbonic acid gas, nitrogen, helium and water vapour in a discharge tube of a few metres length and which includes a plane parallel plate of germanium having a thickness of approximately 2 mm as output coupling window and also as a reflector. The discharge tube has a diameter of maximally 10 mm, the water vapour pressure is from 0.3 to 0.4 Torr and the ends of the discharge tube are connected by a narrow communication tube in which no discharge takes place.

3 Claims, 2 Drawing Figures



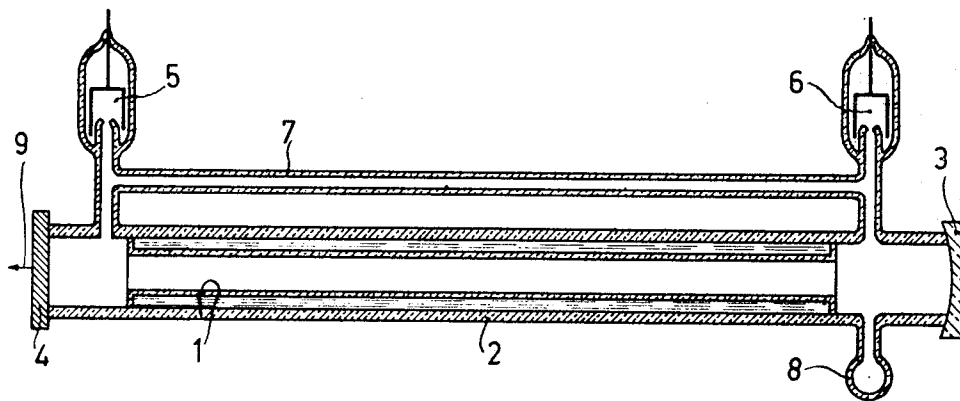


fig. 1

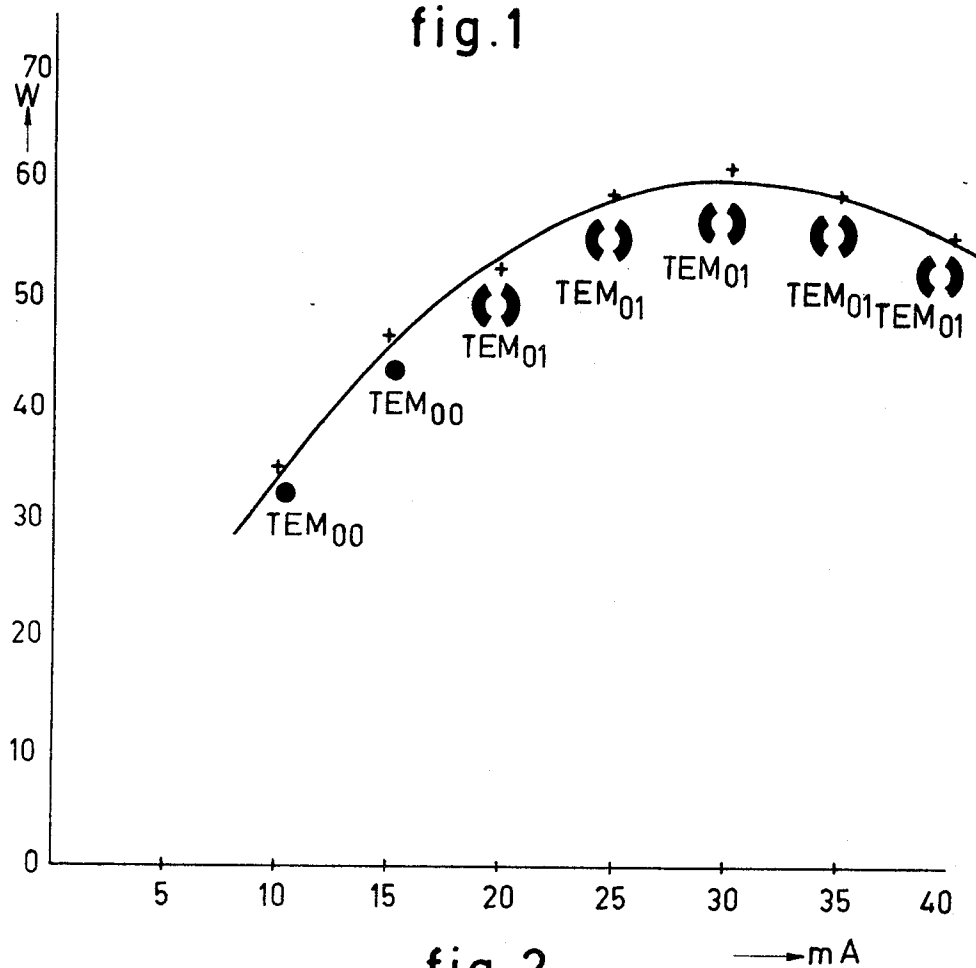


fig. 2

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DEVICE FOR PRODUCING STIMULATED INFRARED EMISSION, AN IRASER, HAVING A WAVELENGTH OF APPROXIMATELY 10.6 μ BY MEANS OF AN ELECTRIC DISCHARGE IN A GAS MIXTURE CONSISTING PARTLY OF CARBONIC ACID GAS, AND ELECTRIC DISCHARGE TUBE DESTINED FOR SUCH A DEVICE

This is a continuation, of application Ser. No. 151,957, filed June 10, 1971, abandoned; which, in turn, is a continuation of Ser. No. 821,417, filed May 2, 1969, abandoned.

The invention relates to a device for producing stimulated infrared emission, an iraser, having a wavelength of approximately 10.6 μ by means of an electric discharge having a current density exceeding 15 mA/sq.cm in a gas mixture consisting of carbonic acid gas, nitrogen, helium and water vapour in a discharge tube of a few metres length, which comprises a plane parallel plate of approximately 2 mm thickness as output coupling window and also as a reflector.

The invention furthermore relates to an electric discharge tube destined for such a device.

A length of a few metres is to be understood to mean herein approximately 1½ metres or more.

Devices as described above are already known. (Philips Technical Review 28, 193-202, 1967). As a result of the output coupling through the plane parallel germanium plate, only one single infrared line occurs which is determined by the rotation level associated with the vibration transition in the carbonic acid molecule. As a result of the presence of the germanium plate which serves not only as an output coupling window but also as a reflector, the frequencies for which the reflection is maximum are approximately 2.10^{10} c/s apart. The lines in the proximity of 10.6 μ , however, are approximately 5.5×10^{10} c/s apart. As a result of this several lines can generally not occur simultaneously.

One of the most important applications of these irasers consists in cutting thin layers, for example, carbon layers on resistance bodies. In this application the drawback is experienced that the intensity of the focused radiation in many cases is not sufficient. For example, for an iraser, length 1.5 metres diameter 20 mm, irradiated power 60 watt continuously, the focal spot, after focusing with a lense having a focal distance of 50 mm, is 6×10^{-2} sq.mm and the radiation intensity is 0.1 Mw/sq.cm.

The large focal spot is the result of the fact that the iraser operates in multimode oscillation; in addition to the one possible purely longitudinal mode, simultaneously or alternately several transversal and radial modes occur which all have the same longitudinal mode number. The mode pattern is then displayed in the focal spot.

It is the object of the invention to provide an improvement of the foregoing arrangement.

According to the invention, a device is provided for producing stimulated infrared emission, an iraser, having a wavelength of approximately 10.6 μ by means of an electric discharge having a current density exceeding 15 mA/sq.cm in a gas mixture. The mixture consists of carbonic acid gas, nitrogen, helium and water vapour in a discharge tube of a few metres length and which includes a plane parallel plate of germanium having a thickness of approximately 2 mm as output coupling window and also as a reflector. The discharge tube has a diameter of maximally 10 mm, the water va-

pour pressure is from 0.3 to 0.4 torr and the ends of the discharge tube are connected by a narrow communication tube in which no discharge takes place.

It has been found in the arrangement according to the invention that as a result of the strong mutual competition at the high current density in the relative gas mixture, of the longitudinal, radial and transversal mode only one of them will occur. With a thus operating iraser, a beam of rays is obtained which after focusing, provides a focal spot with therein only the pattern of that single mode, so that the radiation intensity in the focal spot is considerably higher than in the known devices.

It is to be noted that for producing radiation having a wavelength of 10.6 μ and approximately 1 W continuous power an arrangement having a 10 mms wide tube is known. The current intensity is only 5 mA. The gas filling is carbonic acid with nitrogen without any addition. As a result of the low intensity several radial and/or transversal modes will occur simultaneously (Applied Physics Letters 9, 174-176, 1966).

The invention also uses the known addition of water vapour but with an optimum pressure which is higher than that with wide discharge tubes of multimode irasers.

Furthermore, the communication tube itself between the ends of the discharge tube forms the subject matter of U.S. Pat. No. 3,611,186. This communication tube serves for counteracting a cataphoretic unmixing.

In order that the invention may be readily carried into effect, it will now be described in greater detail, by way of example, with reference to the accompanying drawing, in which:

FIG. 1 diagrammatically shows an iraser discharge tube according to the invention and

FIG. 2 graphically shows the results obtained with said tube.

In FIG. 1 a quartz tube 1 has a length of 152 cm and an inside diameter of 10 mm. 2 is a jacket for water cooling. 3 is a concave reflector which is provided at its surface with a gold layer, radius of curvature 240 cm. 4 is a flat germanium plate, thickness 2 mm. 5 and 6 are platinum electrodes in side tubes. 7 is a communication tube, inside diameter 3 mm, between the side tubes. 8 is a rod of zeolite saturated with water vapour. The gas filling consists of 2 torr CO₂, 4 torr N₂, 8 torr He and 0.4 torr H₂O. With a discharge current of 10 to 35 mA through the tube, in which the operating voltage varies from 19 to 18 kV, a beam 9 emerges with a wavelength of approximately 10.6 μ and an intensity of well over 30 to 60 Watt, the mode pattern is displayed in the focused beam for the single mode occurs at the measured points being shown in FIG. 2.

At 10 and 15 mA, this pattern is a dot of the TEM₀₀ mode, so a purely axial mode; at the higher current intensity this is an assembly of two circle sectors of the TEM₀₁ mode, the first transversal mode. Upon focusing the beam of 60 W with a lens of 50 mm distance, a focal spot was obtained of 7.10^{-3} sq.mm, hence a radiation intensity of 0.8 MW per sq.cm, 8 times as high as in the known devices.

What is claimed is:

1. A device for producing stimulated infrared emission having a wavelength of approximately 10.6 microns comprising a discharge tube including a germanium plate output coupling window disposed at one end thereof, said plate also serving as a planar reflector,

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and a concave reflector disposed at an opposite and thereof, means for providing an electric discharge in said tube for obtaining a single mode output at any current density exceeding an operating current density range over 15 M⁴/sq. cm in a discharge tube, said discharge tube containing a gas mixture consisting of carbon dioxide, nitrogen, helium and water vapor, said discharge tube having a length to diameter factor not in excess of the ratio of the discharge length to the discharge tube diameter, said tube having a length of at least 1.5 meters and a maximum diameter of 10 mm, said length to diameter ratio and the strong mutual competition at the aforementioned high current density range in said gas mixture of longitudinal, radial, and

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transverse modes determining a single mode output at any specific current density within the operating range, said tube also having therein a water vapor pressure from 0.3 to 0.4 torr, the ends of said discharge tube being connected by a narrow communication tube in which no discharge takes place for counteracting cathoretic unmixing.

2. A device as claimed in claim 1, wherein at one level of current density only the purely axial mode occurs.

3. A device as claimed in claim 1, wherein at one level of current density only the first transversal mode occurs.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3768036 Dated October 23, 1973

Inventor(s) WILHELMUS JACOBUS WITTEMAN et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

IN THE CLAIMS

Claim 1, line 6, "and" in the second occurrence should be --end--

line 16, "mm" should be --mms--

line 23, "torr" should be--Torr--

Signed and sealed this 27th day of August 1974.

(SEAL)
Attest;

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Attesting Officer

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Commissioner of Patents

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