Discharge-pumped gold-vapor laser operating in a low-temperature range using chloroauric acid as a lasant

Hiroshi Taniguchi and Hiroshi Saito
Department of Electronic Engineering, Faculty of Engineering, Iwate University, Ueda 4-3-5, Morioka-shi 020, Japan

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Laser oscillation has been obtained from a discharge-pumped gold vapor at 627.8 nm of a neutral gold atom in a low-temperature range of about 70 –150 °C by using chloroauric acid as a lasant. A laser is operated by successive pulsed discharges of a storage capacitor through a spark-gap switch. Excitation is done in an aperiodic pulse train with a compact device by a boosted-ac (50 Hz) high voltage of up to 5.4 kV rms. A maximum laser peak power of about 1.3 W and a laser-pulse energy of 27 nJ are obtained.

Gold-vapor lasers have been observed and investigated previously.[1–5] The lasants used in previous studies were metallic gold (wires and pellets). In some of these previous studies, exploding wires[1] and sputtering with a special cell[5] as the source of the gold vapor were used, and successful results at room temperature were obtained in the latter case.

A typical operating temperature of a discharge-pumped gold-vapor laser is 1600 °C. A laser using gold compounds allows operation at a lower temperature. In this letter experimental results of a study using chloroauric acid as a lasant are presented. To our knowledge, this is the first successful use of a volatile compound as the lasant for a gold-vapor laser.

An experimental setup similar to that described in previous reports[6,7] was used. A laser tube with Brewster windows at both ends was constructed of Pyrex or quartz-glass tubing having a 1.25-cm i.d. and a gain length of about 20 cm. An optical resonator of 55 cm spacing was formed by a flat dielectric-coated backreflector with high reflectivity and an output coupler of a flat dielectric-coated mirror with 1.3% transmittance at 627.8 nm. A nichrome wire heater was wound outside a portion of the discharge tube, and ceramic sheets were wrapped outside the tube for thermal shielding. The discharge-tube temperature (T_t) at the central position of the exterior of the laser tube was measured by a chlomelalumel thermocouple. Viton "O"-rings were used for gas sealing of the connections in the laser tube. Small pieces of chloroauric acid ($HAuCl_4 \cdot 4H_2O$, 99% pure, purchased from Kanto chemical Co., Inc.) were placed in the discharge tube thus eliminating the need for laser beam vignetting. Flowing He gas through the gas-inlet port was used as a buffer gas in order to carry the discharge products which were exhausted by a vacuum pump through the gas-outlet port of the laser tube. The internal gas pressure of the tube (p) was kept at about 4 Torr throughout the experiment.

The laser was operated by successive pulsed discharges of an energy storage capacitor ($C = 4$ nF) through a spark-gap switch of an air-blown type.[6] This was done in an aperiodic pulse train as a boosted ac (50 Hz) high voltage of up to 5.4 kV rms was switched directly by the spark-gap switch. The switch was operated at a repetition rate of about 10 kHz during each half cycle of the 50 Hz-ac.

A laser oscillation at 627.8 nm (corresponding to a neutral gold atom; $6p^2P^0_{1/2} - 6s^{22}D_{3/2}$ transition) was found to have started at a discharge-tube temperature of about 70 °C, and persisted up to 150 °C. The laser was operated for about 30 min with a single fill of $HAuCl_4 \cdot 4H_2O$ of about 300 mg. The laser-pulse waveforms typically exhibited a pulse duration (FWHM; full width at half maximum) of about 15–20 ns, which was measured with a calibrated biplanar phototube (Hamamatu Photonics R1193U-02) and a storage oscilloscope (HP 1744A, 100 MHz) system. The waveforms are shown in Fig. 1. The maximum peak power and pulse energy (per pulse) of a laser-output pulse measured with this system were about 1.3 W and 27 nJ, respectively.

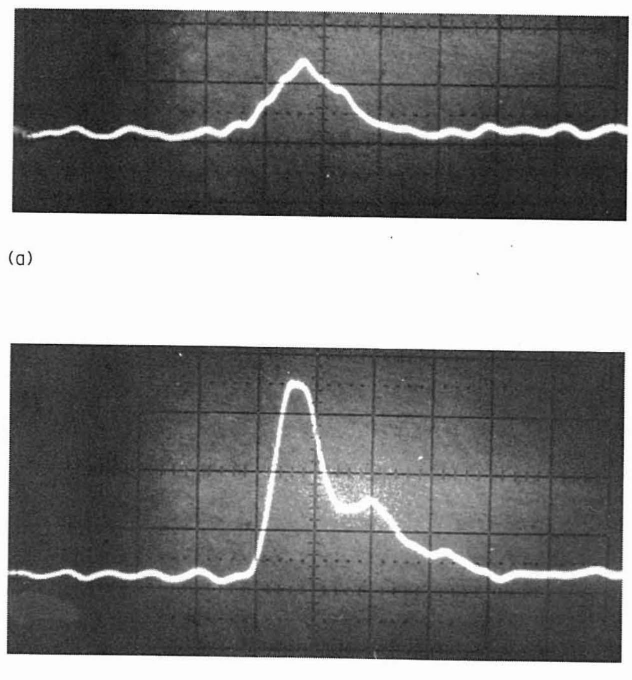

FIG. 1. Typical oscilloscope traces of laser-output waveforms in the gold-vapor laser using chloroauric acid as a lasant. Tube temperature, $T_t = 120$ °C in (a) and $T_t = 140$ °C in (b). He buffer gas flow rate is 110 cc/min, applied voltage, $V_a = 5.4$ kV (rms) and internal pressure of the tube, $p = 4$ Torr are fixed throughout the experiments. Horizontal scale is 10 ns/div.

In a trial experiment a flat dielectric-coated mirror with 5% transmittance at 627.8 nm was used as the output coupler. It seemed that the characteristics of the burn pattern and the beam intensity in the laser output were better and higher, but the operating temperature region became narrower than when the output coupler with 1.3% transmittance was used.

In the present experiments, the best performance of the laser oscillation was obtained at the flow rate of the He buffer gas of 110 cc/min, it was the upper limit of measurements in the present gas-flow-meter system. For flow rates in the range 0 –110 cc/min the laser performed better as the flow rates were increased.

A neutral gold-vapor laser can be realized at low operating temperature by using a volatile compound at low temperatures but the pulse repetition rate of the laser is low, a few pulses per second. Modification of the high-voltage power supply and the laser tube may lead to improved laser performance.

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