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Studying the Effect of Using Assist Gas with Low Power CO_2 LaserGlass Drilling

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ABSTRACT: *Since the invention of laser in 1960 and the laser play an important role in material processing due to its exclusive properties. Brittle material drilling is one of the important facilities that laser presents. In this work a 20W, CW, 10.6 μm, CO_2 laser were used to drill 2mm thick, soda lime glass, using the air as assist gas.The laser exposure time, laser power, and using assist gas were the varied parameters during the work. Then the drilled holes were examined using optical microscope.*

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I. INTRODUCTION

Lasers find wide applications in the mundane to the most sophisticated devices, in commercial to purely scientific purposes, and in life-saving as well as life-threatening causes[1].
Laser hole drilling has rapidly become an inexpensive and controllable alternative to conventional hole drilling methods such as punching, wire electrical discharge machining (EDM), broaching or other popular destructive methods[2]. Laser hole drilling in materials such as polyimide, ceramic, copper, nickel, brass, aluminum, borosilicate glass, quartz, rubber and composite materials offer high accuracy, repeatability and reproducibility for the medical device industry, semiconductor manufacturing and nanotechnology support systems[3, 4, 5].
In laser drilling, there are a lot of parameters such as pulse duration, peak power, pulse repetition rate, focal position and pulse shape, which should be controlled to obtain the desired whole characteristics[6].
The Aim of this work is studying the effect of using assist gas as a cooling technique during laser glass drilling process for different laser power and irradiation time.

II. EXPERIMENTAL WORK

A 2mm thick soda lime transparent glass were irradiated with a low power CW CO_2 laser of 20W maximum output power, 10.6 μm wavelength, 0.8mm spot diameter and 50mm focal length. The laser irradiation time was programmable controlled. Also an electrical air pump was improved with the laser machine to supply a fresh air as an assist gas for any material process.
The microstructural pictures were examined using Olympus biological microscope with four total magnification powers (40,100,250, 1000)X. The whole microscopic system can be seen in Fig.(2.3):
The glass specimens were drilled using different laser powers, exposure times, and with/without assist gas. The minimum laser beam diameter was placed at the specimen surface layer.
Four different laser powers were used (5, 10, 15, 20) W, while the laser exposure time used (1-10) sec with 1sec increment till a complete drilling process is obtained, except one case were drilling was not appeared even in 100 sec irradiation time.Then the drilled points were examined and captured using the microscopic system.

III. RESULTS AND DISCUSSIONS

Generally two mean effects were recognized between the using and not using assist gas, andthey were:
A. Cracks Shape: during the glass drilling, the cracks shape was either have a ramify shape begins from the hole edges and grows radially outside, which appeared when laser irradiated without using assist gas(Fig.1a),while annulus or an arc crack shape around the hole (usually one or two cracks almost) appears when assist gas pumped during irradiation of laser, (Fig.1b). This behavior may be explained due to complicated relation between the cooling role of pumped air and the glass thermal expansion.

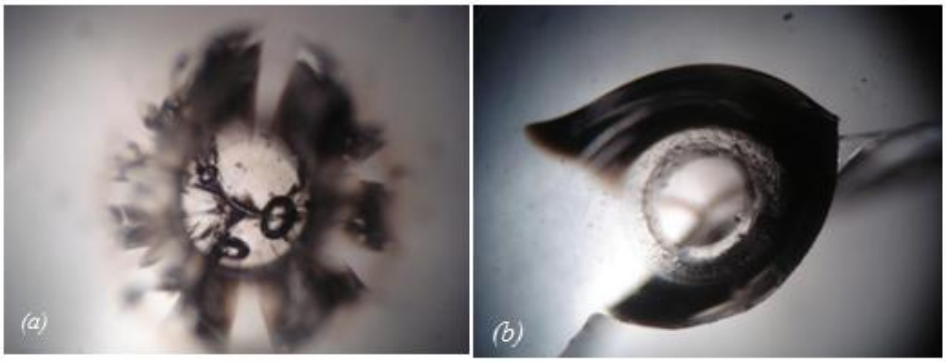

Figure (1): *Fracture Shape around the Drilling hole; (a) Ramify shape, (b) Arc shape.*

B. Drilling Surface: the using of assist gas during irradiation gives smoother drillingshape, and this is due to theair role as an ejector for the molten material particles that mayre-solidified on the hole surface when no assist gas used.

On other hand the power effect with and without assist gas was as below:

1.1 Irradiation with 5W laser power (I = 995.22 W/cm^2):

A-Without using assist gas: There was incomplete drilling, and the specimen has been crashed at (9) sec exposure time, Fig.(2).

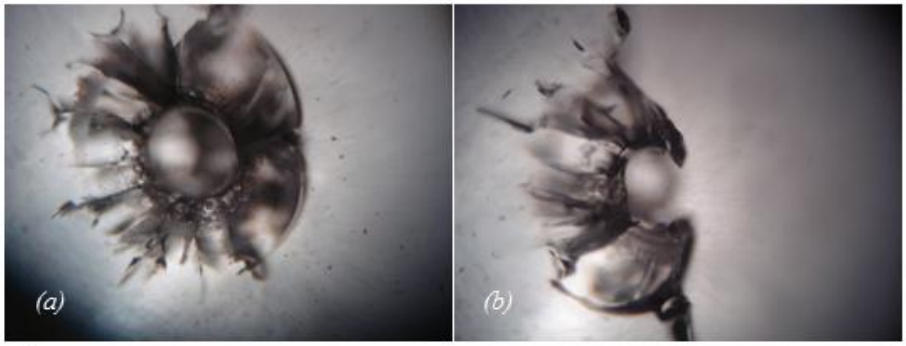

Figure (2): 5W laser power drilling withoutusing assist gas: (a) exposure time = 7sec, (b) exposure time = 9sec

B-Using assist gas: only small notches were appeared till 25sec irradiation time,(Fig.3a), then incomplete drilling was appeared even at exposure time of 100secand the cracks begin to appear under the surface, (Fig. 3b).

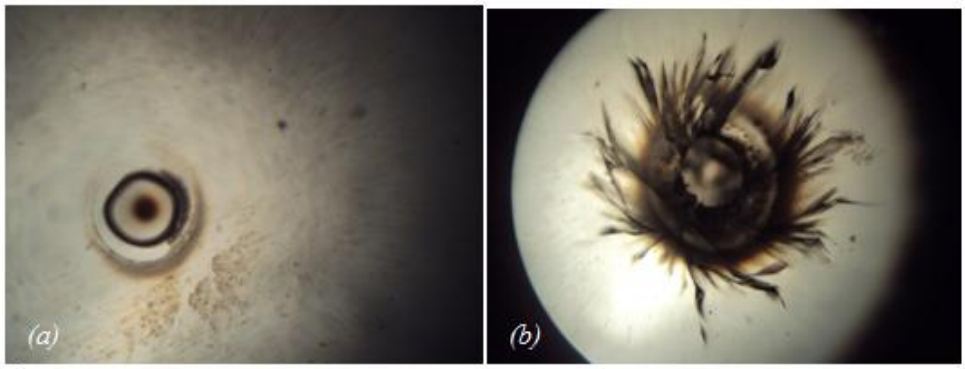

Figure (3): 5W laser power drilling using assist gas: (a) exposure time = 25sec, (b) exposure time = 100sec

This can be explained due to the high cooling rate supplied by the assist gas flow, as compared with the low intensity of the applied laser.

1.2 Irradiation with 10 W laser power (I =1990.44 W/cm^2):

A. Without using assist gas: Till 6 sec exposure time there was an incomplete drilling on the specimen, and then a complete hole was obtained after 7 sec exposure time, as shown in Fig.4.

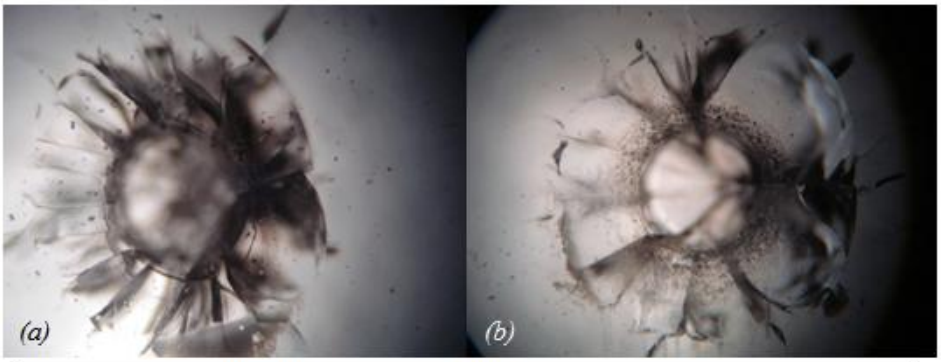

Figure (4): 10W laser power drilling without using assist gas: (a) exposure time = 4sec, (b) exposure time = 8sec

B. Using assist gas: the drilling was completedat 8 sec exposure time, as can be seen in Fig.(5).

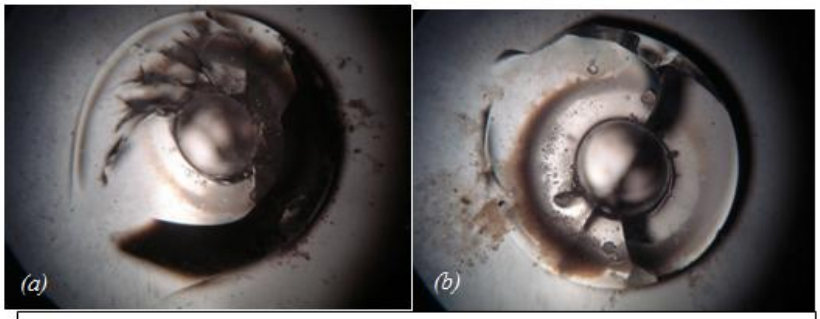

Figure (5): 10W laser power drilling using assist gas: (a) exposure time = 5sec, (b) exposure time = 8sec

Above this power and for irradiation time more than 3 sec the use of assist gas is very essentially to get a complete drilled hole and to protect the system lenses. Otherwise the material vapor will be deposit on the lens surface causing a high decreasing in the output power and may damage this lens.

1.3 Irradiation with 15 W laser power (I = 2985.66 W/cm^2) :

A. Without using assist gas: An exposure time less than 6 sec gives an incomplete drilling, then drilling complete at the sixth second, but at second after the specimen brokendue to cracks growth, Fig.(6).

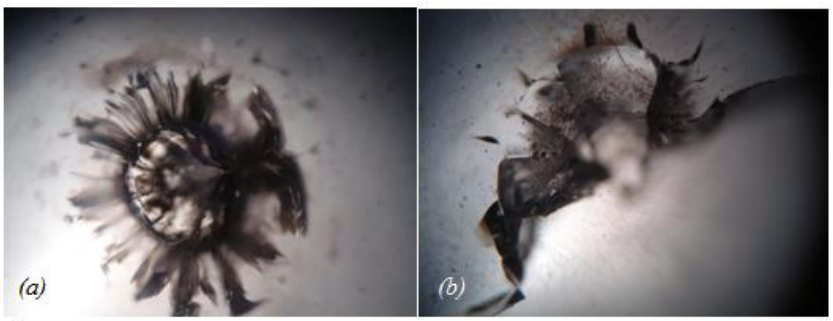

Figure (6): 15W laser power drilling without using assist gas: (a) exposure time = 2sec, (b) exposure time = 7sec

B.Using assist gas: A clear drilled hole was obtained at 7 sec irradiation time as can be seen in Fig.(7).

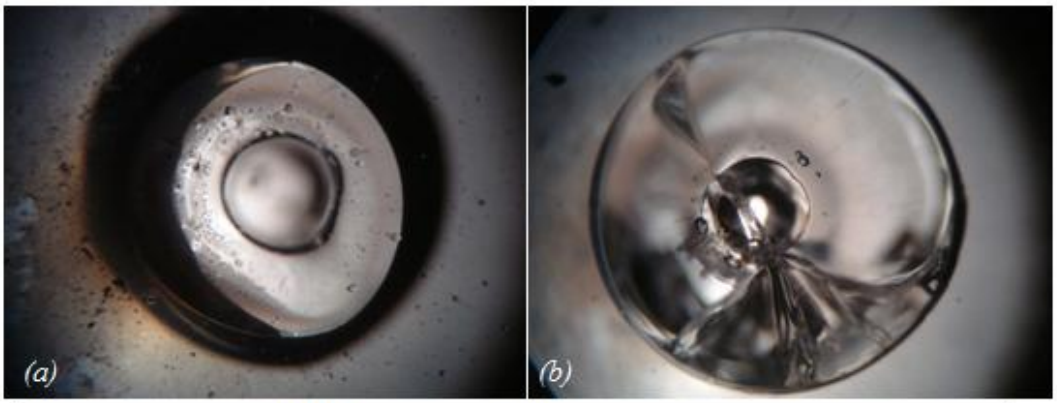

Figure (7): 15W laser power drilling using assist gas: (a) exposure time = 2sec, (b) exposure time = 7sec

1.4 Irradiation with 20 W laser power (I = 3980.89 W/cm²) :

A. Without using assist gas: After five second laser irradiation through hole has been obtained, Fig.(8).

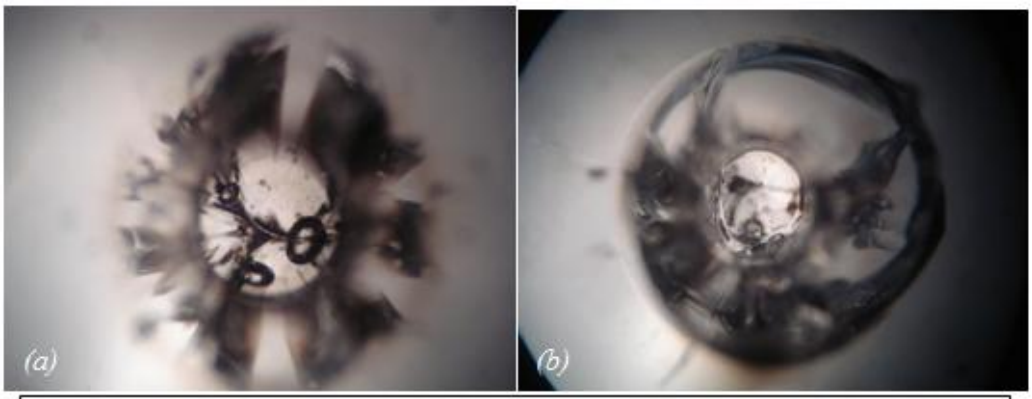

Figure (8): 20W laser power drilling withoutusing assist gas: (a) exposure time = 2sec, (b) exposure time = 5sec

B. Using assist gas: There was a through hole after 5 secirradiation time, Fig.(9).

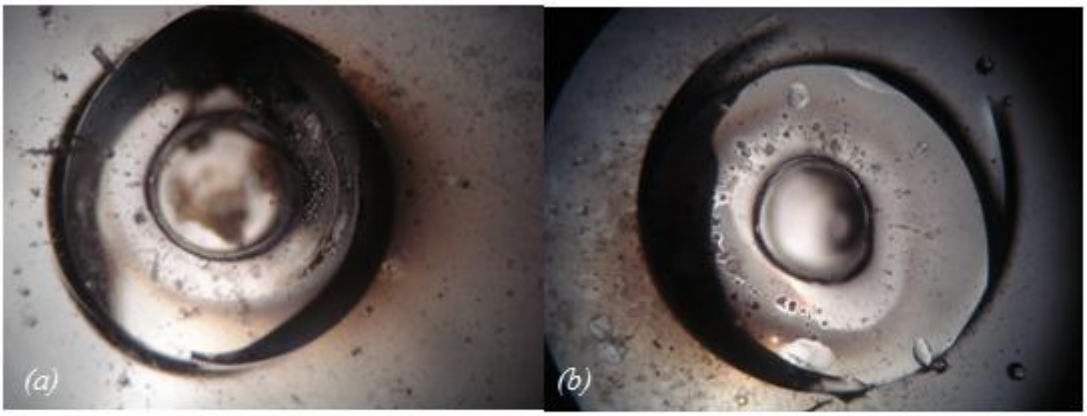

Figure (9): 20W laser power drilling using assist gas: (a) exposure time = 1sec, (b) exposure time = 6sec

IV. CONCLUSIONS

At the end of this work the following point can be concluded:

1. No drilling can be obtained with 5W power when assist gas is used.
2. The drilling shape is finer when using assist gas, but this is at the expense of power.
3. During this work; the batter conditions were 15W, 6sec and with using assist gas.
4. The using of assist gas is safer for the system optics at laser powers more than 10W.

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