The evaluation of laser cleaning of silica nanowires

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Abstract. The aim of this work is to investigate the laser cleaning of contaminants from surfaces of silica nanowires. Experimental parameters affected particle removal were explored using pulsed fiber laser radiation at a wavelength of 1064 nm. The laser beam was focused and scanned across the surfaces of the nanowires. The interaction between laser radiation and a certain thickness in the contaminant layers was analyzed. The results suggest that low laser fluencies allow greater control over the removal depth reducing the risk of damage. The cleaning efficiency was determined. The laser cleaning technique can open up completely challenges in applications of nanophotonics.

Keywords: Laser, Laser cleaning, Silica nanowire

1. Introduction

Behaviors of photons in nanoscale waveguides exhibit exceptional phenomena in nanophotonics. In recent years, the novel idea of optical circuits has been explored. There are several progresses to produce small scale waveguides, including semiconductor nanowires, plasmonic waveguides, and silica nanowires [1-3].

The silica nanowire has been demonstrated as a potential solution to produce the nanoscale optical waveguides [4 -7]. The interaction of light and matter in the nanoscale plays an important role to achieve an all-optical circuit.

To fabricate the silica nanowire, many techniques and technologies including flame-brush taping, directly from bulk glasses and CO_2 heated oven have been studied [8 -11]. Each technique reveals results in nanoscale size, surface roughness and mechanical properties.

In this paper, we investigate the use of infrared (IR) laser for contamination removal occurred by the fabrication techniques. A new pulling method is introduced to fabricate the wires. The removal of contamination occurred during the fabrication using a Q-switch fiber laser will be demonstrated.

2. Methodology

The silica nanowires for the demonstration on laser cleaning were fabricated with a gravitational pulling set up shown in Figure 1. The conventional optical fiber is held by the mounts on the pulling stage. The ends of the fiber were pulled by the tension force during heated by the CH_3OH fueled flame. The fabricated wires obtained by the gravitational drawing serve as the samples for the laser cleaning application.

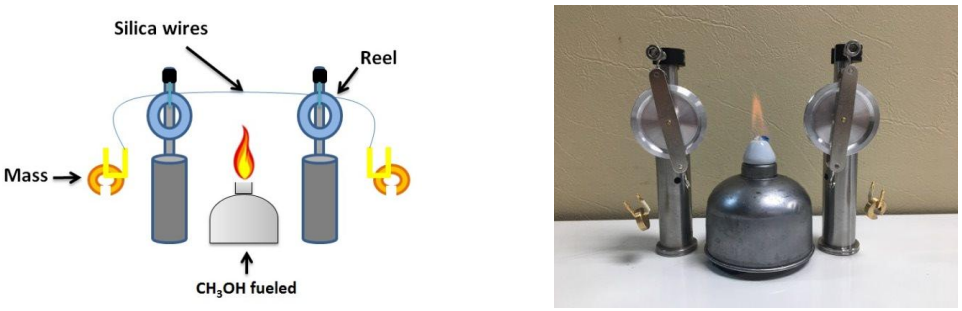

Figure 1. Schematic diagram of the gravitational-pulling fiber drawing process.

To study the contamination removal, a Q-switch fiber laser operating at repetition rate between 50 kHz and 100 kHz was used as a tool. It should be mentioned that the duration of the laser pulse was 100 ns (FWHM) Q-switched. The maximum energy of the laser pulse was 0.5 mJ per pulse. Figure 2 shows the experimental setup. The laser beam with a diameter of 100 microns was scanned on the fabricated wire.

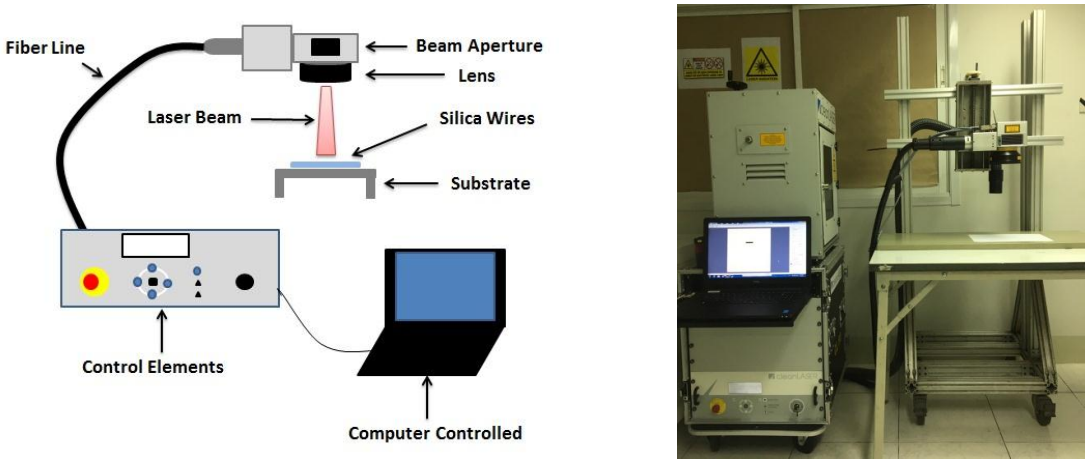

Figure 2. Schematic setup of the laser cleaning fabricated wires.

3. Results and Discussion

The gravitational-pulling fiber drawing process was preliminarily studied. In this paper, the minimum diameter size of 10 microns was obtained. As shown in Figure 3, the contamination of the fabricated wires

was occurred due to the heat flame. For further use of the wire in nanophotonics application, the contamination removal is subjected to be performed.

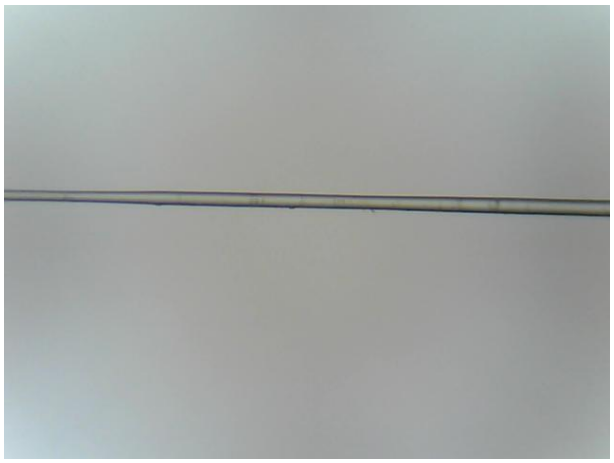

Figure 3. A microscope picture of a fabricated wire.

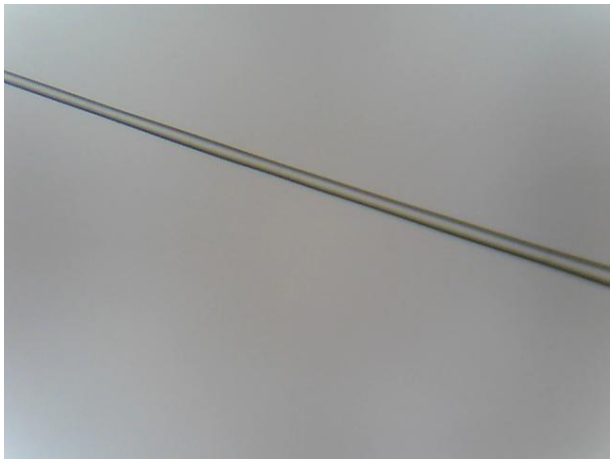

Figure 4. The fabricated wire cleaned by a Q-switch fiber laser.

The removal of the contamination occurred by the fabrication process can be achieved by using the IR laser. At a fluence of 0.3 Jcm^{-2}, the contamination removal is possible. Figure 4 shows the excellent result of the contamination removal using the Q-switch radiation. The high absorption of the contamination to the IR laser radiation allows the ablation process exhibiting the sufficient removal.

4. Conclusion

This work shows the feasibility of the contamination removal of fabricated silica wire using Q-switched fiber laser. The silica wires were fabricated by the gravitational drawing. The contamination removal by

Q-switched fiber laser can be achieved at very low laser fluence. The interaction between contamination and the IR radiation allows the ablative removal process with no appearance of heat zone effects.

5. References

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