Direct 9.3 µm CO_2 Laser Consolidation of FHD Silica for Planar Devices

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Flame Hydrolysis Deposition (FHD) is a traditional route to deposit layers of doped silica onto the surface of a substrate for planar lightwave circuits. To form a uniform layer of fused glass the deposited soot must be consolidated, typically within a furnace at temperatures between 1200 °C and 1400 °C. This thermal processing is not localised as the temperature of the entire wafer is raised. This could be an issue for thermally sensitive, metallic or active photonic structures. This also limits the materials used for the substrate and requires the silica glass to have sufficient dopants to permit consolidation. CO_2 lasers have previously been used for smoothing and polishing of silica [1,2] and were performed with CO_2 lasers operating with a wavelength of 10.6 µm. Silica however has a large absorption peak between 9 to 9.5 µm [4]. This paper demonstrates that using a CO_2 laser operating at 9.3 µm allows for highly localised heating and consolidation of FHD silica soot on a silicon wafer, this greatly reduces processing time and relaxes the constraints on dopants and substrate used in FHD, and to knowledge of the authors is the first example of FHD consolidation with a 9.3 µm laser.

Figure 1(a) shows the consolidation procedure. A silica soot was deposited through FHD onto the surface of a 6" silicon wafer with a 15 µm thermal oxide layer. A 100 W CO_2 laser operating at a wavelength of 9.3 µm was focused onto the sample achieving a spot size of ~80 µm. A galvanometer actuated mirror was used to raster scan the beam across the surface of the sample to form 5 mm^2 areas of consolidated silica. The scanning speed of the mirror was set at values from 100 to 1500 mm/s, and the duty cycle of the laser was set at values from 10 to 100% to produce the consolidated array of squares shown in figure 1(b). With higher laser powers the soot initially consolidates, however during the raster scan enough heat is introduced to the consolidated areas to cause significant cracking. At lower laser powers the light is absorbed by the surface of the FHD soot, leaving a layer of soot between the substrate and consolidated surface. For duty cycles in the range 20 to 60 % and scan speeds from 200 to 400 mm/s the soot is consolidated down to the substrate with no cracking evident.

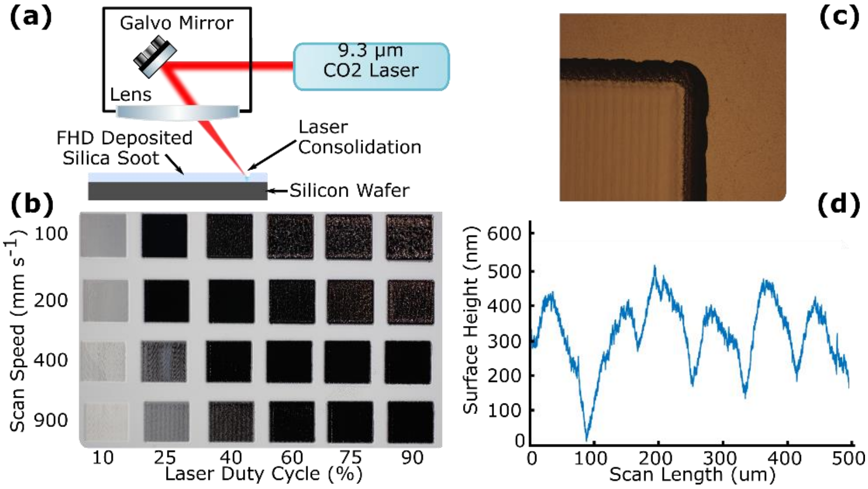

Fig. 1 (a) shows the system for consolidating FHD silica with a 9.3 µm CO_2 laser. (b) shows a parameter matrix for different mirror scan speeds and laser duty cycles. (c) is a light microscope image showing the corner of a consolidated square and the substrate beneath. (d) is the surface profile of a consolidated area measured with a stylus profiler.

After consolidation the remaining silica soot was removed and a stylus profiler used to measure the surface of the consolidated regions. Figure 1(d) shows the profile over a 500 µm length perpendicular to the lasers raster scanning direction of one of the smoothly consolidated squares. The smoothest profile roughness was calculated to be R_a = 76.7 nm for the square consolidate at 25% duty cycle with a scan rate of 200 mm/s. It would be possible to improve this roughness through further processing with the CO_2 laser.

We shall present our latest results including improved surface roughness, localised consolidation onto traditionally challenging substrates and investigations into the fusing of low dopant silicate glass layers.

References

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