Supplementary Information for

Femtosecond laser fabrication of Black Quartz for infrared photodetection applications

Raffaele De Palo, Annalisa Volpe, Pietro Patimisco, Andrea Zifarelli, Angelo Sampaolo, Antonio Ancona, Hongpeng Wu, Vincenzo Spagnolo

*Corresponding authors: annalisa.volpe@poliba.it, vincezoluigi.spagnolo@poliba.it, wuhp@sxu.edu.cn

This file includes:

Figs. S1 to S5

Table S1

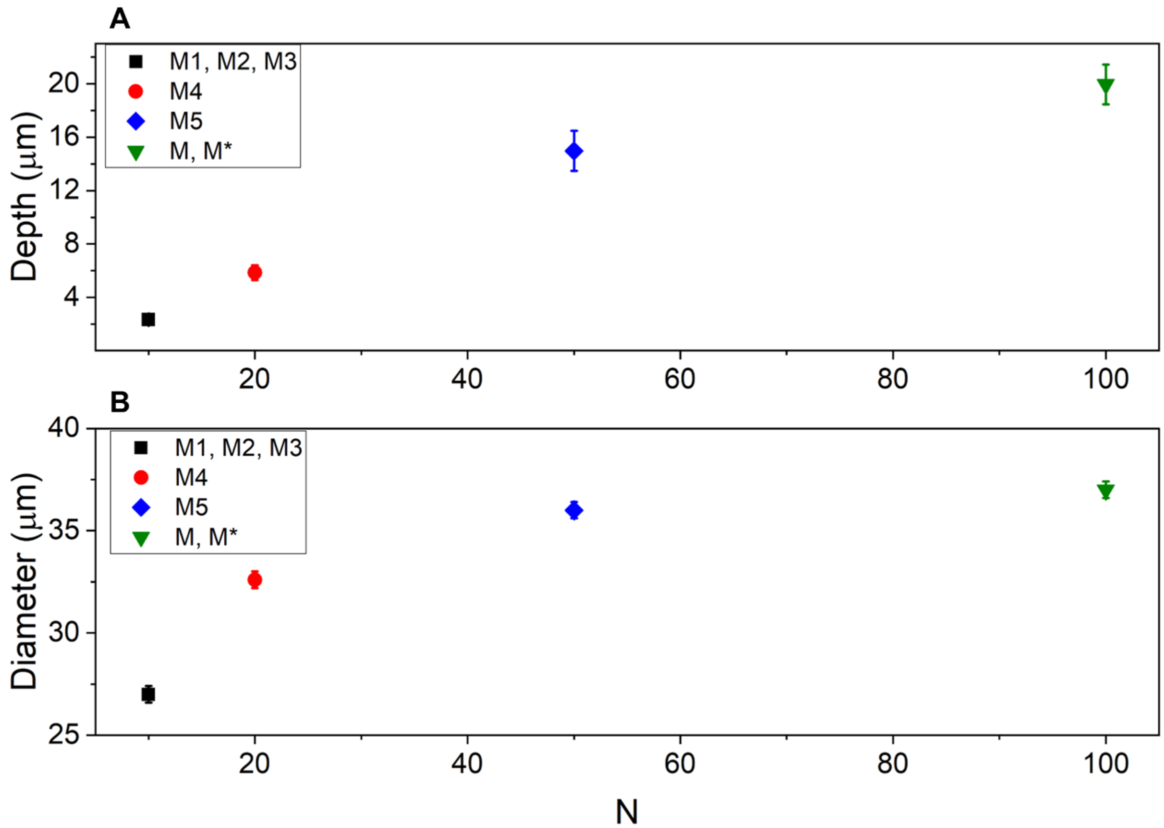

Fig. S1. Craters characterization. The depths and diameters of the craters were measured using an optical microscope (Nikon Eclipse E600) by evaluating the depth and the lateral distance between the top edge and the bottom position of the crater, respectively, with the optical microscope in focus. In the two graphs, depth (a) and diameter (b) are plotted as a function of the number of pulses *N*. Both plots show that depth and diameter grow with increasing *N*.

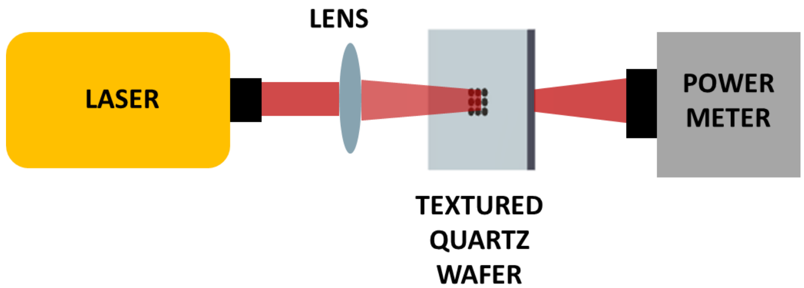

Fig. S2. Matrix characterization setup. Schematic representation of the spectral characterization setup used for measuring the absorption spectrum of the matrices applied on the quartz wafer. Six lasers were used to measure the absorbed radiation at six different wavelengths: 1.39 µm, 3.29 µm, 4.56 µm, 5.26 µm, 7.79 µm, 10.50 µm. The laser beam was focused using a plano-convex lens with 50 mm focal length and anti-reflection coating in the wavelength range 2 µm – 13 µm. The laser beam was focused on the surface of the quartz wafer, on each matrix, and the transmitted power was measured by a power meter. Five commercially available laser sources were selected, each providing a perfectly collimated output beam with a diameter of approximately 2 mm. A plano-convex lens with a short focal length of 50 mm and an AR coating in the 2-13 µm spectral range was sufficient to achieve a beam waist of less than 300 µm at the focal plane for all five beams, where the quartz sample will be placed. The intensity distribution of the laser spot was measured by positioning an infrared pyrocamera (Ophir, Spiricon III) with a spatial resolution of

100 μm at the lens's focal plane. The beam diameter was calculated as three times the standard deviation of the Gaussian fit of the intensity profile, extracted along both the x- and y-axes.

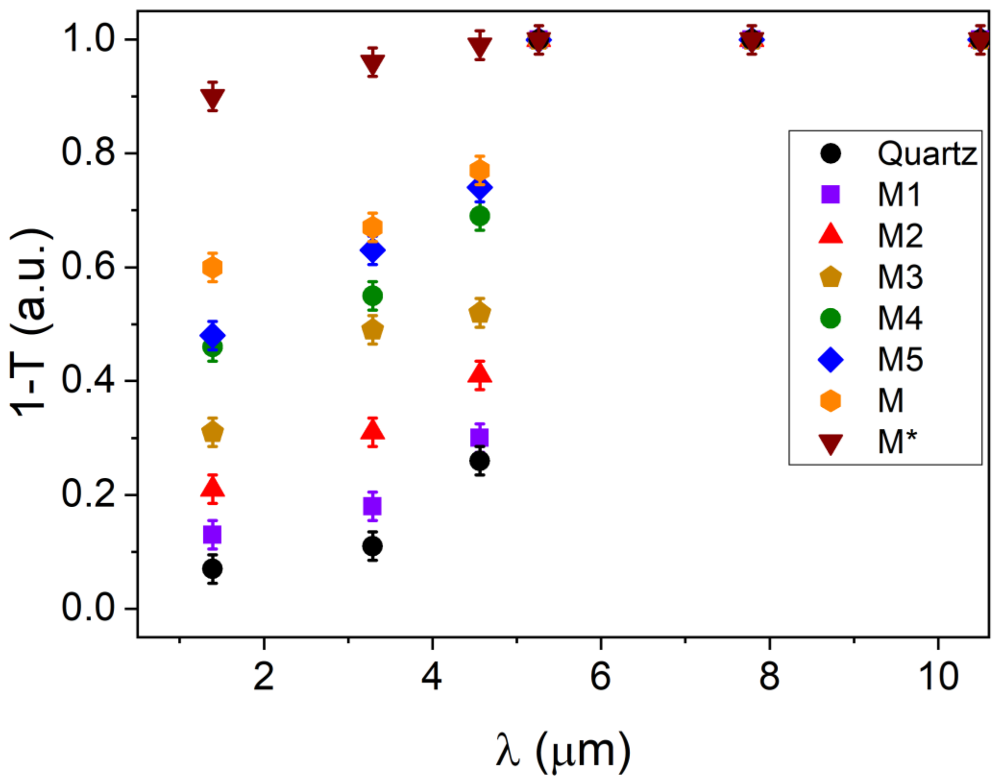

Fig. S3. 1-*T* spectra. 1-*T* spectrum of all the texturing matrices measured with the setup in Fig. S2. The reported pure quartz absorption spectrum was measured with the same setup.

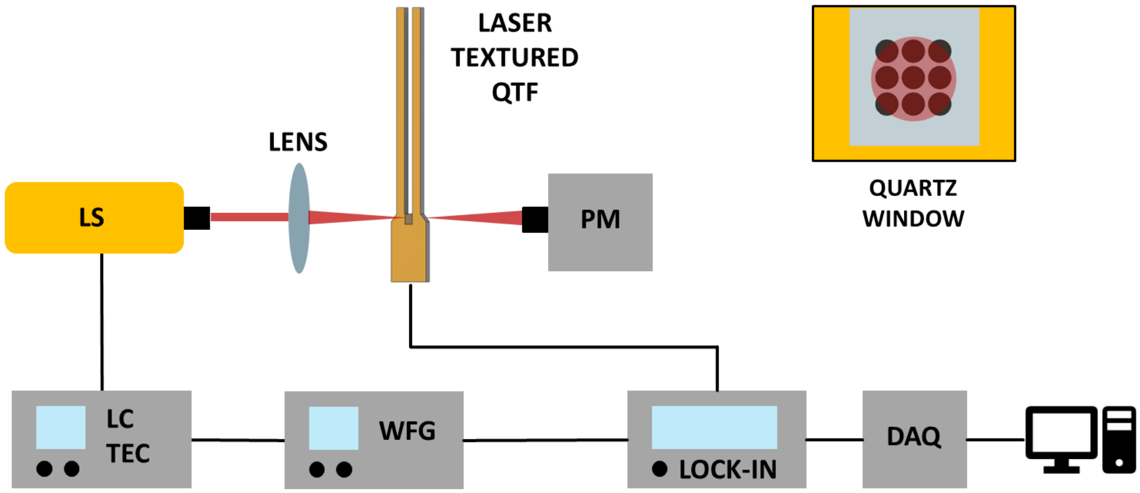

Fig. S4. Water detection setup. Spectroscopic setup employed to test the textured QTFs for water detection. The laser beam was focused on the quartz window of the QTF where the texturing was performed, as shown in the inset image. A f = 50 mm lens (AR coating 2 – 13 µm) was used as focusing element. The path length from laser to QTF was fixed at 10 cm. Detection was performed in wavelength modulation (WM) regime. The laser injection current was modulated with a sinusoidal dither at frequency $f_0/2$, where f_0 is the resonance frequency of the QTF. A 10 mHz ramp signal was then applied to the injection current in order to reconstruct the absorption feature. Both stimulations were produced by a waveform generator. The QTF signal was then demodulated using a lock-in amplifier with integration time set at 100 ms. The signal from the lock in was then digitalized using a DAQ card connected to a PC. A power meter was used for alignment purposes detecting the laser radiation transmitted through the QTF quartz window.

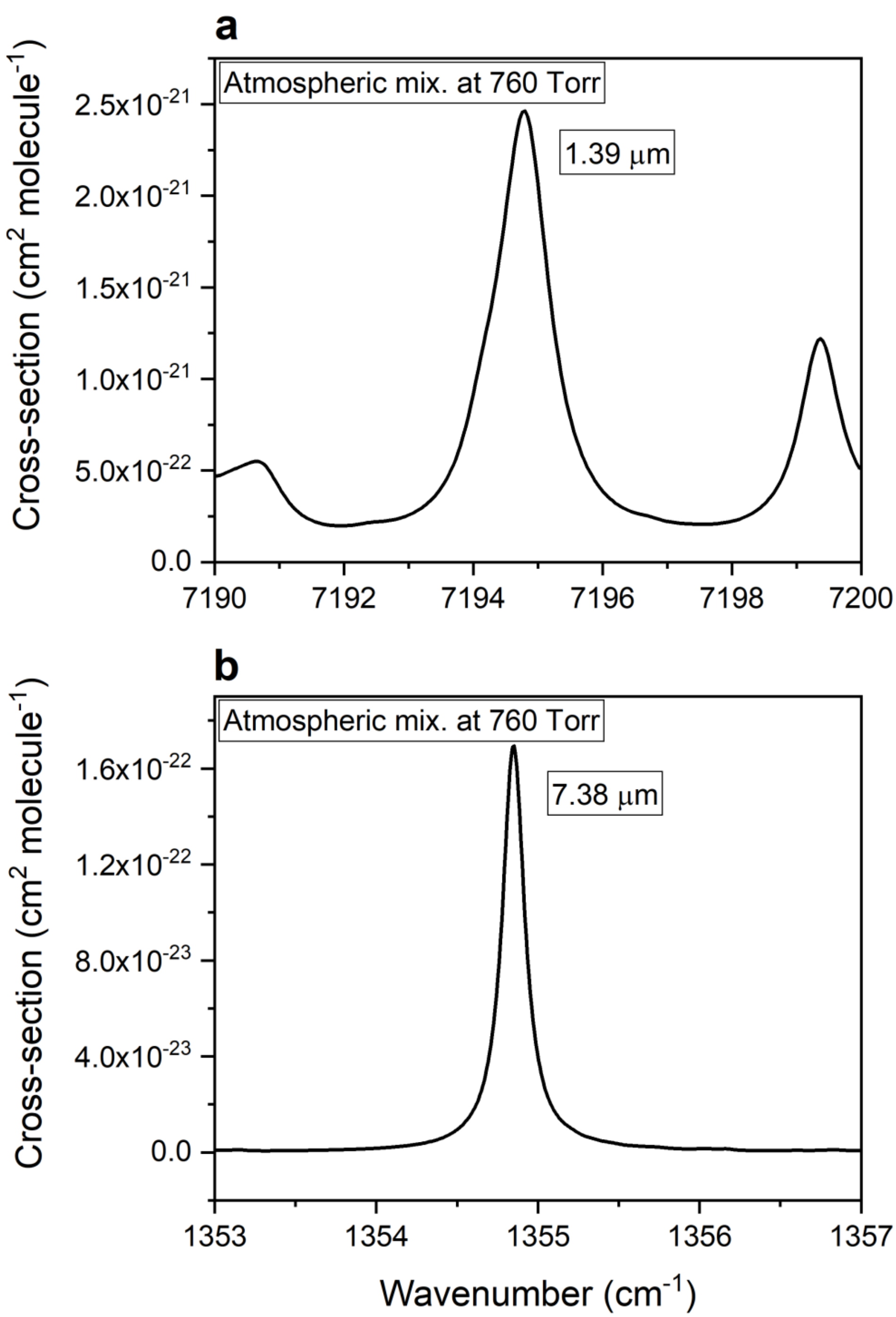

Fig. S5. Water features simulations. HITRAN simulation of the two-water absorption features targeted for detection using the black quartz QTFs, (a) at 1.39 μm and (b) at 7.38 μm. Both features were simulated for an atmospheric mixture and at 760 Torr.

Laser	**λ (µm)**
Nanoplus DFB 1392	1.39
Nanoplus S/N 1650/16-27 ICL	3.29
Nanoplus 3205/16-04	4.56
Nanoplus 346804-28	5.26
Corning HZ-HLL-17	7.79
HHL-15-59	10.50

Table S1. Laser sources. List of the lasers employed in the characterization of the matrices with their central emission wavelength.