LA – CRDS

University of Copenhagen

The laser ablation system1 (1) comprises a high-energy pulsed laser that produces fs pulses enabling ‘cold’ laser ablation5. Optical elements guide and focus the laser beam into the ice sample (30mm x 30 mm x 550 mm) which is placed on a sample holder (2) mounted on a motorized linear stage (3) for micro-metric translational movement. An enclosure (4) for the optics is inserted and attached to the ablation chamber (5), which faces both the ice surface and the CRDS analyzer inlet (6) through a collection line using dry air as the carrier gas.

Laser Ablation Craters on Ice

Laser ablation results in the formation of craters. Crater morphology indicates the physical processes that occurred during the ablation and depends on the laser parameters, such as pulse width, pulse energy, ablation time and repetition rate. These parameters have to be optimized to achieve an adequate gas phase sample and prevent meting and recrystallization when sampling ice.

Ablation Chamber

The ablation chamber and the transfer line are the two connecting parts of the LA-CRDS system and the CRDS analyzer. A specially designed ablation cup slides onto the ice surface when the ice sample moves during a continuous measurement, for robust gas phase sample delivery to the CRDS analyzer.

LA – CRDS Coupling

University of Copenhagen (UCPH)

Proof of concept experiment carried out at DTU (Danmarks Tekniske Universitet) using a custom-made cryo-cell, a fs-laser and the L-2130i CRDS analyzer by PICARRO (fig.5).

Figure 1: fs LA-CRDS system. Conceptual design of an ablation chamber coupled with the CRDS analyzer.

Figure 2: Laser ablation craters on an artificial ice surface while using varying laser parameters of the fs-laser operating at 50 kHz.

Figure 3: Ablation chamber (gray) for the fs LA-CRDS measurement on ice (blue).

Figure 4: Water vapor level change as a response to different ablation time. (Proof of concept experiment at DTU)

Figure 5: Water vapor level change as a response to different ablation time. (Proof of concept experiment at DTU)

Figure 6: Water isotope signal acquired by the fs LA-CRDS system.

References and Acknowledgements

1K.M. Peersen, 2021, ‘Developing a Method for High Resolution Water Isotope Measurements in Ice Cores’, MSc Thesis, University of Copenhagen, Denmark


4The Laser Ablation system was designed and constructed with the help of people from the Mechanic and Electronic workshop of University of Copenhagen. Thanks to Ciarian Siemens, Pern Larikman, Nicolas Stolf, Alessandro Boneto, Rimi Dallaym, Agnesse Patrini, Marco Peschutti who worked at the CoFascari University and contributed to the LA-CRDS coupling.

Outlook

- High quality crater imaging for their better characterization will lead to a better understanding of the cold ablation mechanism.
- Integration of the new designed ablation chamber into the L-2130i LA-CRDS system will increase the LA-CRDS system’s capability to deal with real ice samples.
- Laser ablation of the LA-CRDS system will be compared with the state-of-the-art laser ablation system’s capabilities.

The Laser Ablation system is used for impurities studies on ice cores when coupled with CRDS. The same system was successfully coupled with the L-2130i CRDS analyzer. Laser ablation using a laser beam spot size of 150μm in a raster scanning mode of a 4.2 mm x 4 mm surface area, resulted in a water concentration of 1000 ppm and water isotope signal values that approach the true value for the standard sample used.