High resolution isotope ratio and elemental depth profiling using UV femtosecond laser ablation

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Depth profiling using laser ablation is limited by the rate of ablation, usually in the range of tens to hundreds of nanometers per pulse[1] depending on the ablation threshold and the pulse energy and wavelength applied and the spot size which is usually limited to ~ 4 µm in diameter. The later one limits the amount of material available for analysis and therefore the detectability.

Short range depth profiling can be performed using secondary ion mass spectrometry and focussed ion beam techniques to depths of ~ 3 µm. Here we developed a technique to determine isotopic and elemental depth profiles in the range from <1 to 60 µm in depth in order to determine elemental and isotopic diffusion profiles in solids using 194nm femtosecond laser ablation coupled to ICP-MS/MC-ICP-MS. The ablation rates of UV femtosecond laser ablation can be controlled to achieve ablation rates for metals and glass which are in the range of 9-23 nm per pulse. Using a circular pattern for ablation combined with a high speed laser shutter[2] a layer having a roughness of +- 100 nm can be removed to a depth of ~ 60 µm . The pattern can be repeated and programmed with interspacing background acquisition intervals for each layer using the open source real time linux program LinuxCNC[3]. Pyrex exhibits with 9nm/pulse the lowest ablation rate using a pulse energy of 0.27 J/cm^2. Removing 25 layers of the surface results in a total depth of 2 µm and a theoretical depth resolution of 80 nm. Isotopic self diffusion profiles have been determined for experimental charges for Li in phosphate glass resulting in diffusion profiles of 40 µm in length (Welsch et al. 2017)[4] which are difficult to determine when using spot analysis in the direction of diffusion. Li diffusion has been determined for intercalated synthetic single crystals of TiS_2 along the crystalographic c-axis with 7 layers over a depth of 3 µm resulting in a depth resolution of 400 nm.

[1] I. Horn, M. Guillong, D. Günther, Appl. Surf. Sci. **182** (2001) 91–102. [2] L.P. Maguire, S. Szilagyi, R.E. Scholten, Rev. Sci. Instrum. (2004). [3] T. Staroveski, D. Brezak, T. Udiljak, Tech. Gaz. **20**, 2013 [4] A.-M. Welsch, H. Behrens, D. Murawski, I. Horn, Zeitschrift Fur Phys. Chemie **231** (2017).