Supplementary Figures

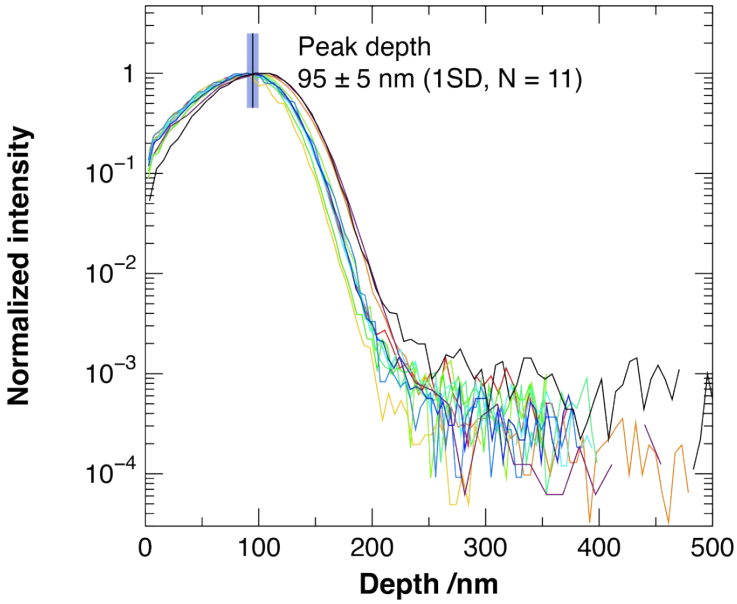

Fig. S1. $^{4}He^{+}$ depth profiles of the HNA-IL analyses repeated 11 times with the peak $^{4}He^{+}$ intensity normalized to 1. The peak depth was 95 ± 5 nm (1SD), with variation due to the reproducibility of the depth measurement of the laser microscope.

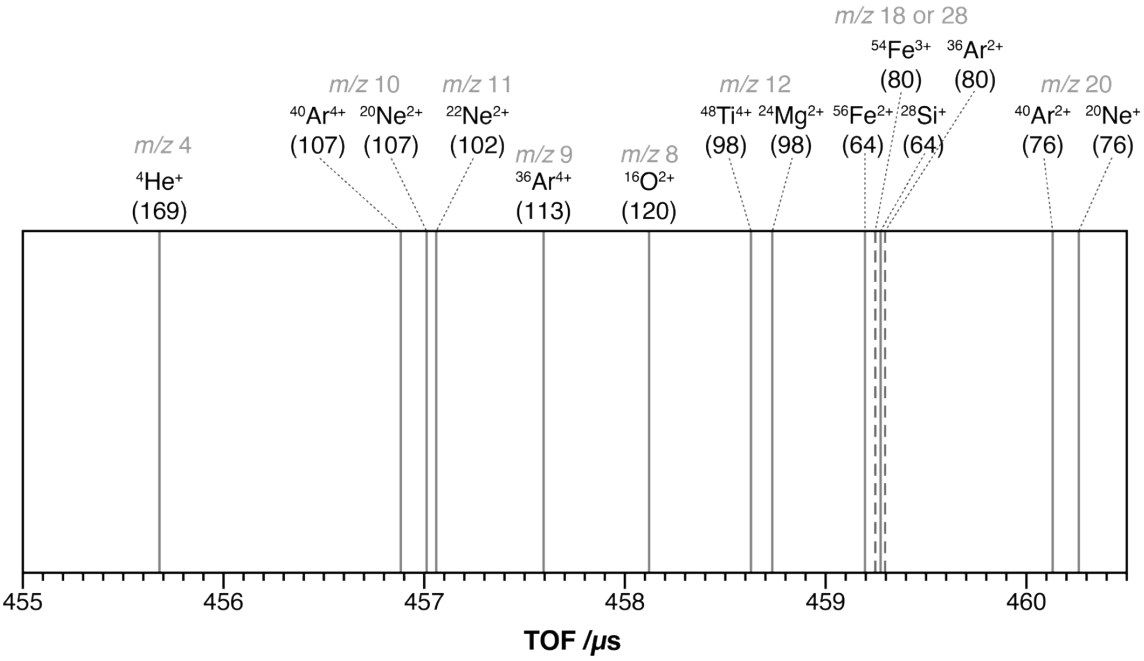

Fig. S2. Calculated TOF for objective ions (*m*/*z* 4, 8, 9, 10, 11, 12, 20, and either 18 or 28.). Numbers written below the ion are the lap numbers for the MULTUM II system.

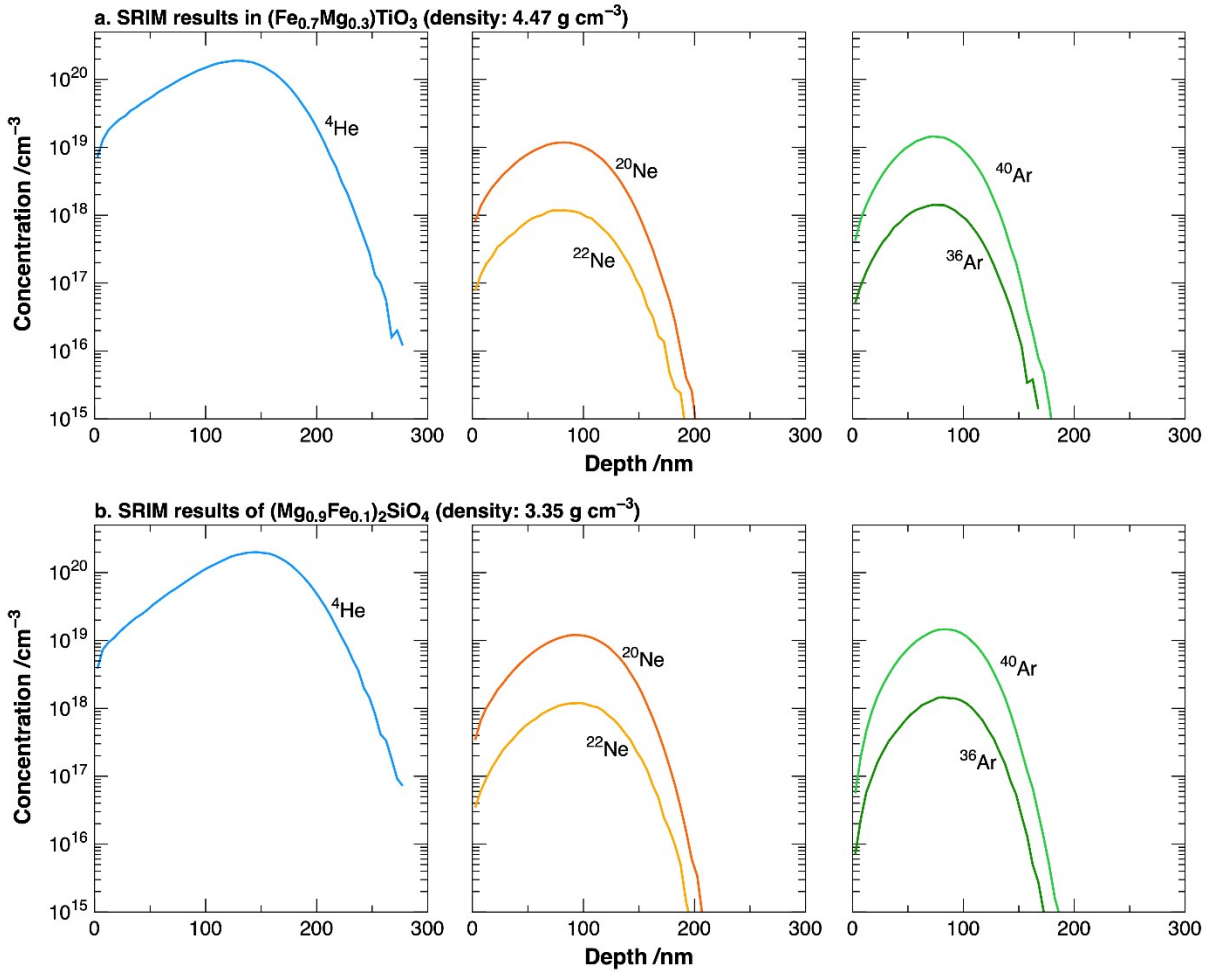

Fig. S3. Depth profiles of noble gases obtained from SRIM simulation. The target materials are (a) $(Fe_{0.7}Mg_{0.3})TiO_3$ with density of 4.47 g cm^{-3} and (b) $(Mg_{0.9}Fe_{0.1})_2SiO_4$, respectively. The depth profiles are obtained by calculating in 5 nm bins.

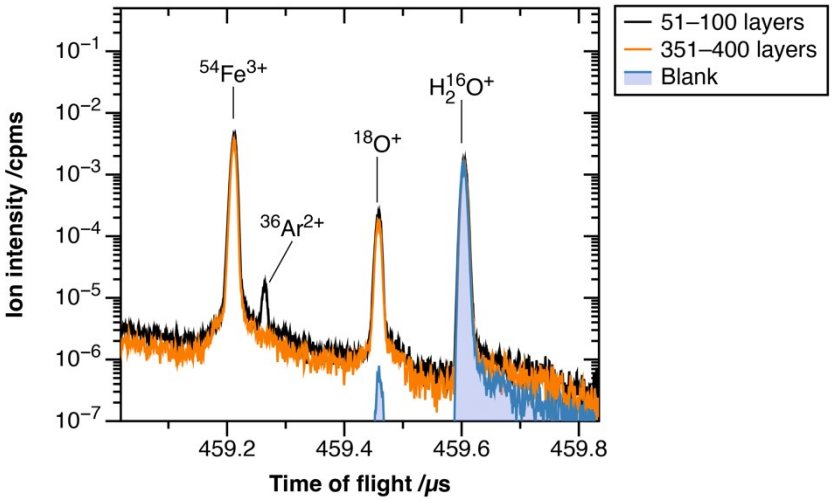

Fig. S4. TOF spectrum of *m*/*z* 18 taken from HNA-IL (Data #5 in Table S3). This TOF window is not measured in Fig. 3.

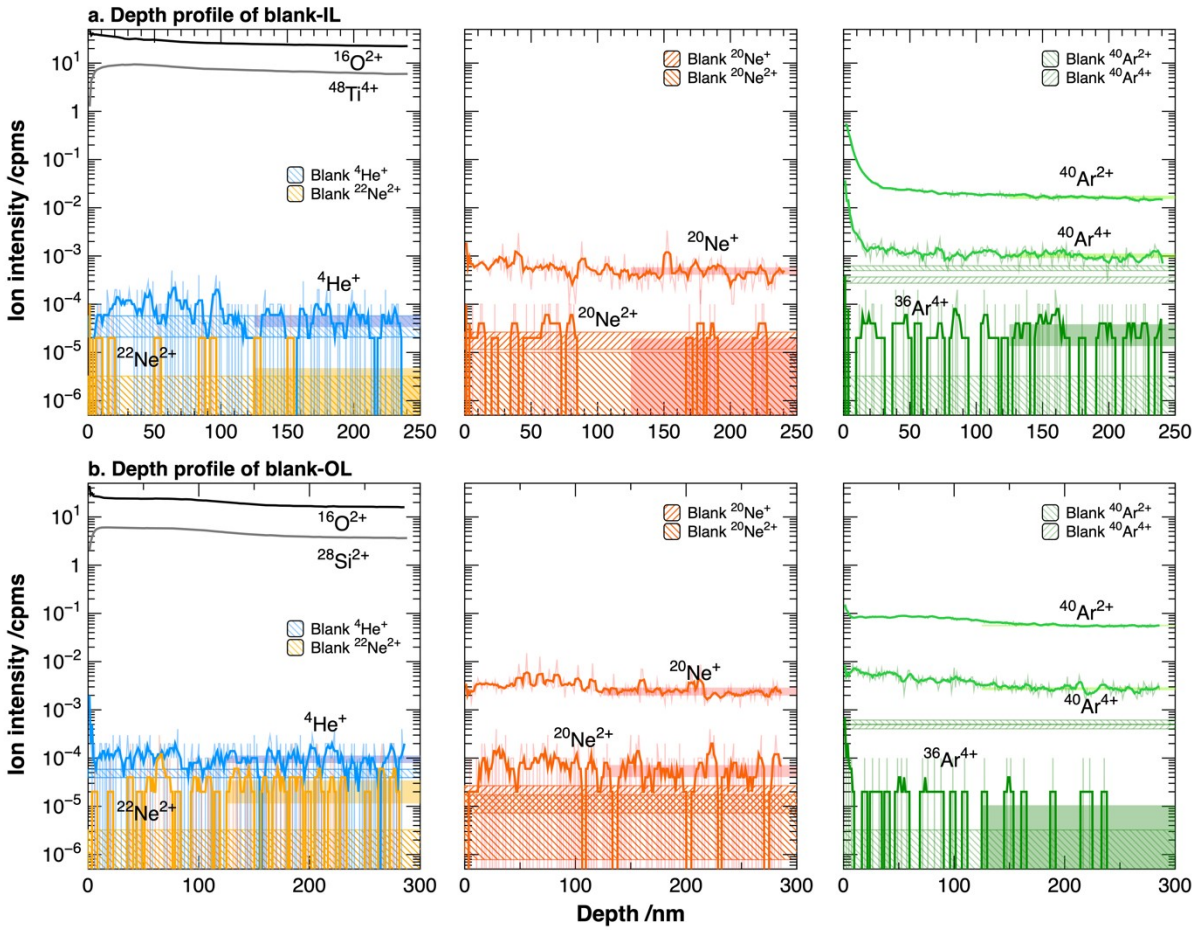

Fig. S5. Depth profiles obtained from (a) blank-IL and (b) blank-OL. The raw data is shown as a light-colored line with the moving average as a dark solid line. The moving average was calculated over an interval of 5 data points. Blank *i*Ms and backgrounds for each ion are shown as a colored range corresponding to the average ± 1SD (Table 2).