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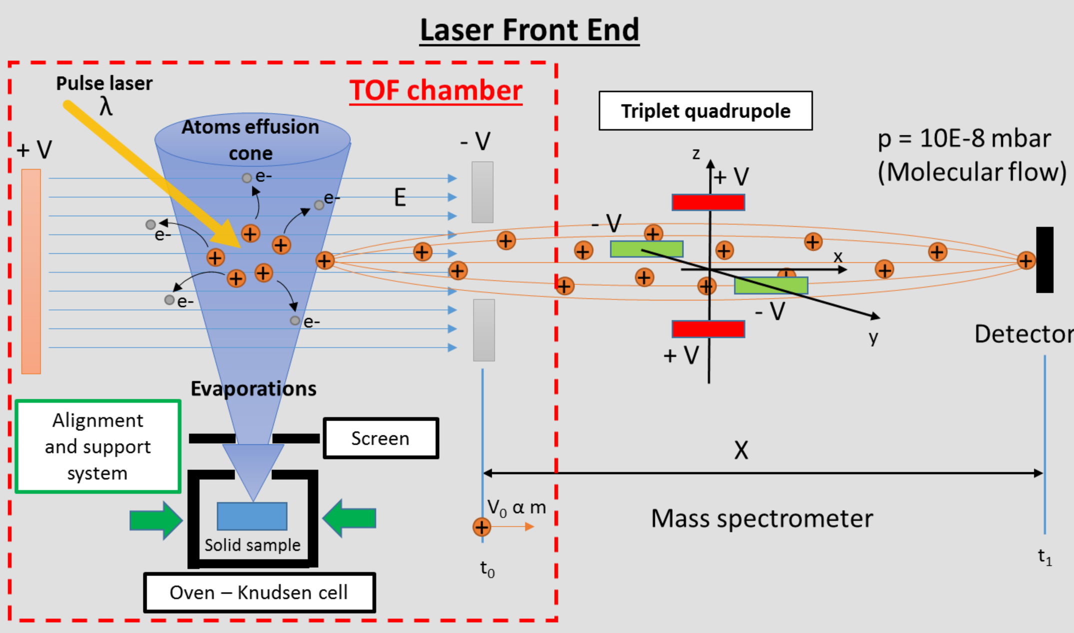
New Calibrated Evaporation Oven for Time of Flight Mass Spectrometer in Offline SPES Laser Laboratory

M. Rossignoli[1,2], D. Scarpa[1], A. Andrighetto[1], M. Campostrini[1], M. Iannelli[5], E. Mariotti[3], P. Nicolosi[4], A. Tomaselli[5]

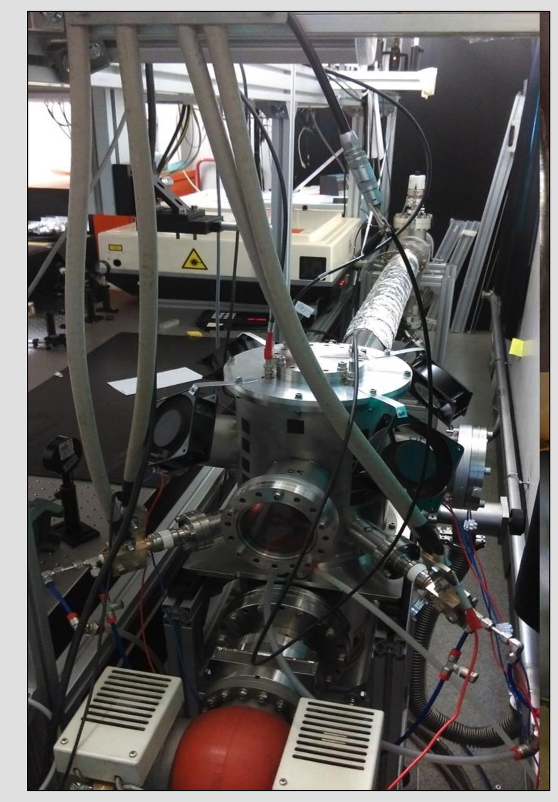
1 INFN-Laboratori Nazionali di Legnaro Viale Università 2 Legnaro 35020 Padova, Italy
2 Dept. Industrial Engineering - University of Padova, Padova, Italy
3 CNISM, University of Siena DSFTA, Siena, Italy
4 Dept. Information Engineering - University of Padova - IFN-CNR UOF Padova, Italy
5 Department of Electrical, Computer and Biomedical Engineering, University of Pavia, Pavia, Italy

The SPES Laser Front End at the offline laser laboratory



The intensity and physical composition of the produced beams in an Isotope Separation On-Line Facility (ISOL) are strongly dependent on the type of method used to ionize the isotopes of interest. The Resonant Laser Ionization technique is one of the paramount techniques due principally to the high mass-selectivity of the process and to the high ionization efficiency that can be obtained in some cases. Respect surface ionization, where several studies were done to evaluate ionization efficiency using current integration method, with low repetition rate lasers the same technique is inapplicable. In this scenario a shot by shot efficiency measurement could help to the laser ionization efficiency estimation. In order to reach this goal an evaporation oven coupled to a ToF-MS is the chosen solution to have constant atom flux production available for ionization.

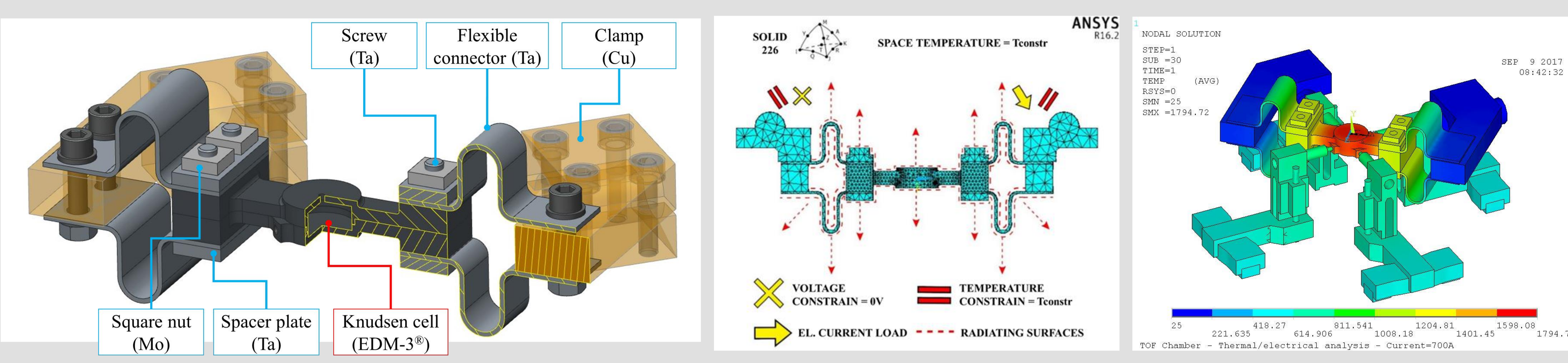
Furthermore, in its final realization, the ToF-MS with the new evaporation oven system will be used, coupled to a standard SPES hot cavity and extraction system, to realize a test bench machine for deeper laser ionization efficiency measurements applicable for the SPES laser ion source.



Evaporation Oven design and simulations

Electro-Thermal design:

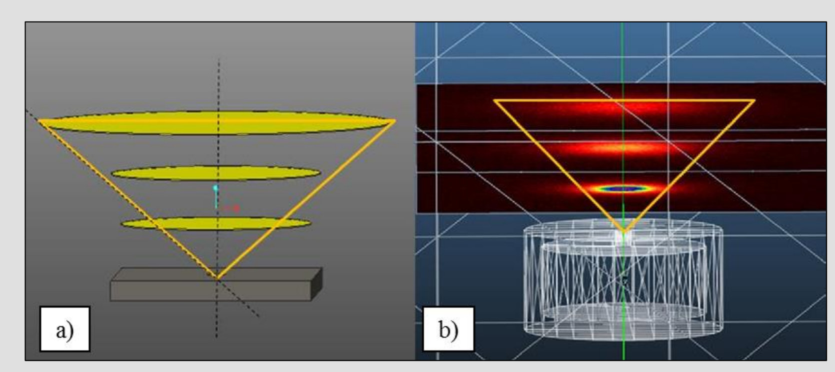
The main feature regards the design of the Knudsen cell is the material selection and its geometry, which determine the satisfaction of two predominant conditions: the temperature and pressure uniformities inside the Knudsen cell. Moreover, the chemical inertia of the material avoid unwanted chemical reactions during the evaporation phase. Since the Knudsen cell is usually heated by Joule effect, a high mechanical strength is required, especially at high temperature.



The maximum temperature reached is approximately equal to 1920 °C and the potential drop between the two electrical feedthroughs is 4,75 V. The maximum temperature provides indirect information of the temperature on the inner surfaces of the cell, which should be higher than the external surface since the presence of thermal radiation in a small enclosure. A temperature of 2000°C, in fact, would guarantee the possibility to evaporate a wide range of species. In the other hand, the maximum potential difference and the current supplied are in agreement with the maximum values allowed by power supply actually available

Vacuum and particle trajectory design (Molflow+®) :

The software, which is based on the Monte Carlo method, is usually adopted for the vacuum analysis, whereas molecular flow occurs. The simulations consist in the discretization of the empty volume surrounds the Knudsen cell. On each surface, once Lambert's emission law was chosen to describe the angular distribution of the desorbed particles, the temperature furnished by the finite element analysis was applied.



Different reference surfaces were implemented in order to evaluate the particles distribution (particle/mm²s) at 5 mm, 10 mm ad 15 mm, which correspond to the distance of the target in the experimental tests. The outgassing rate, namely the number of lead particles evaporated per unit time from the inner surface of the cell (the lower one) were gradually increased to reach the aforementioned temperature-pressure condition. For each outgassing rate corresponds one simulation, in which 12 Ghits was registers (Ghits is the total number of collision inside the reference volume).

Thermal and evaporation tests

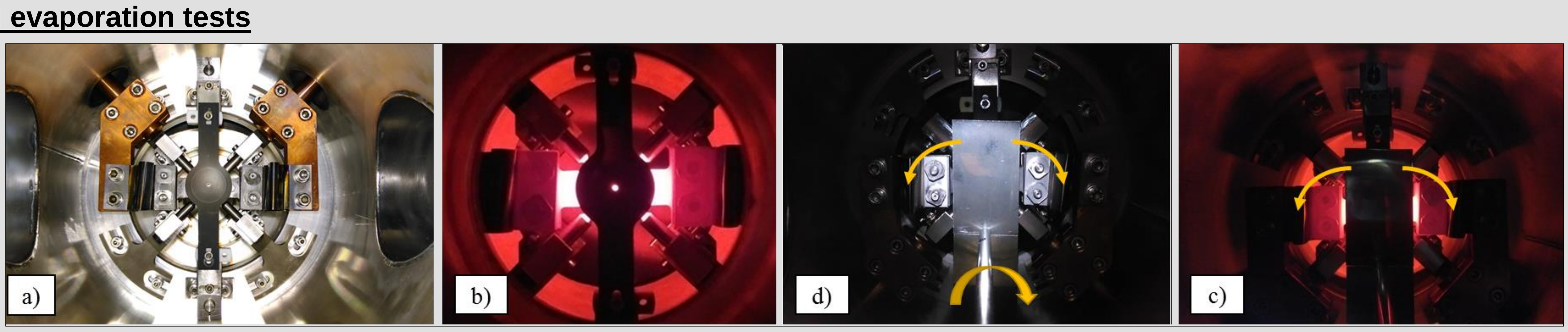


***Figure 1**: a) Cell in the ToF-MS; b) Cell heated @ 1100°C; c) Rotable deposition plate facing the cell; d) Deposition measurements running*

The deposition target is a combination of two molybdenum sheets (0.25 mm of thickness) assembled on a rotatable rod. This configuration allows to deposit on a first target plate and check the residual deposition on a second control plate, after nominal deposition time elapsed. The regulation system allows to control the distance of the target from the graphite shield and also the possibility to switch between target and control plate by a rotation of 180° of the rod The results of the most significant deposition test is presented in Fig. 2. The first picture is referred to the molybdenum control plate positioned above the shield, thus the cell evaporation hole, after four hours from the test starting to prove no deposition of Aluminum. The second one, instead, shows the aluminum spot obtained in the first four hours of the deposition test. The first remark concerns the clear difference in terms of colors. In fact, the first spot, is the result of the thermal radiation which through the shield hole reaches the target surface. In the second target, contrary, the "white" recall the presence of aluminum oxide. A SEM image and EDS scanning have been then performed along different path to understand the nature of the deposition spot .

The presented tests are the first step for a study of a method which permits to characterize the laser ionization efficiency. As aforementioned, many parameters affect the entire process and ongoing experiments are aimed to discover the influence of each parameter on the other. After this preliminary deposition test, the first ionization test using aluminum will be performed and the designed extraction system will be tested in the next year.

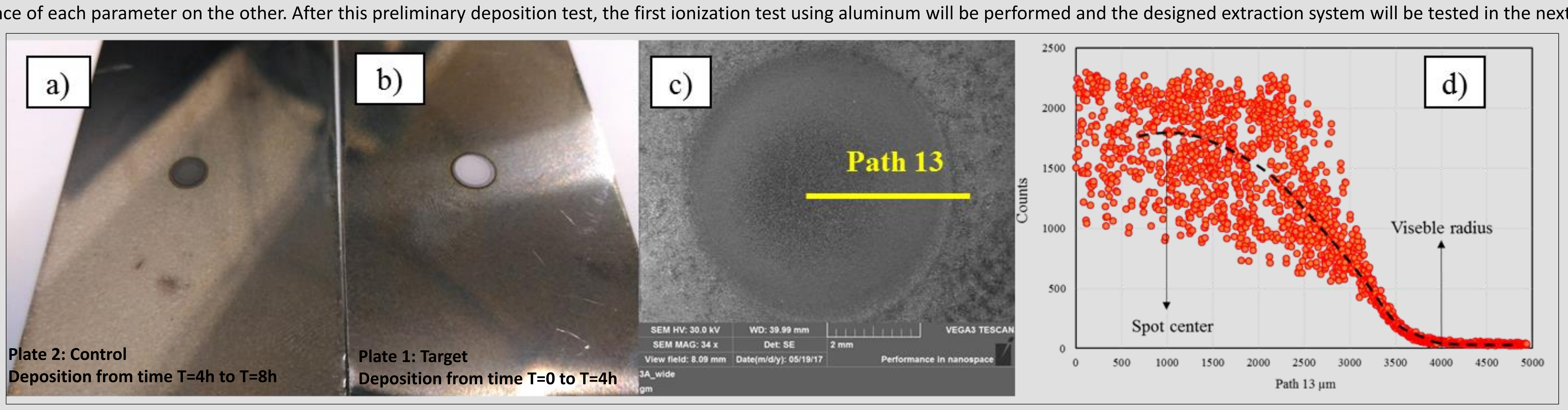


***Figure 2**: a) Control plate without Al in the spot; b) Al deposition on the target plate; c) SEM Microscope image of the spot; d) SEM-EDS Al deposition measurements*