A New-Type Standard Leak Element Using Femtosecond Laser Micromachining

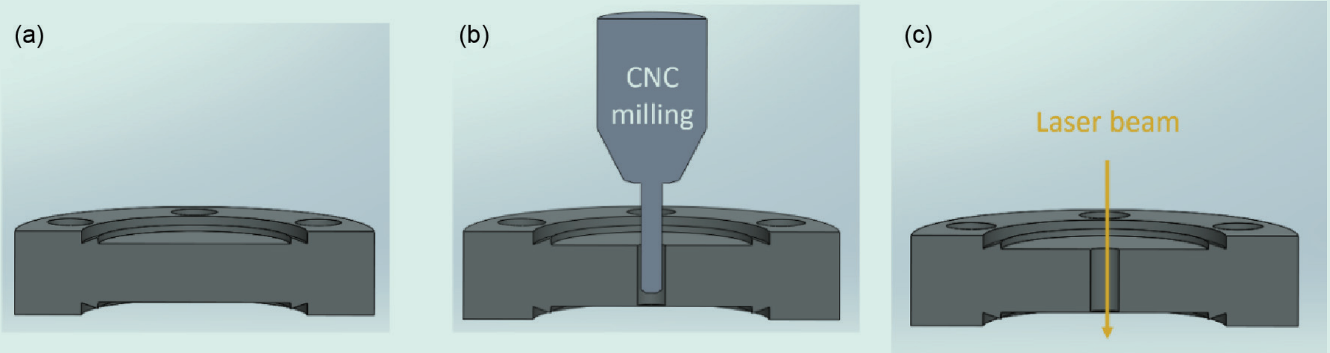

Fig. 1: Manufacturing processes of a flange-type SLE: (a) preparation of a double-sided 16CF flange; (b) CNC (computer numerical control) milling to drill a blind hole on the flange, and (c) micro-hole drilling through the blind hole using femtosecond laser micromachining. [Reproduced from Ref. 2]

A vacuum device with a known artificial leak, herein called a standard leak element (SLE), is a useful tool that can serve to supply a reference gas flow for the calibration of vacuum instruments (*e.g.*, ionization gauges, leak detectors and residual gas analyzers) and the measurement of pumping speeds for a vacuum pump or a vacuum system. Many studies have consequently been conducted to develop such devices. The NSRRC vacuum group has been collaborating with the ultrafast dynamics laboratory of the National Chiao Tung University to develop successfully a flange-type SLE (**Fig. 1**); the new design can be compatible with an ultra-high vacuum environment to overcome the issues related to the use of an epoxy resin sealant in a SLE of other types (*i.e.*, large rates of outgassing and low baking temperature < 120 °C). To measure the conductances of the SLE for various test gas species at varied inlet pressure, five non-condensable gases (H_2, He, CH_4, N_2 and CO_2) were introduced into a measurement chamber through the SLE and the measurement results show (**Fig. 2**) the minimum conductance 2.54×10^{-9} L s^{-1} for N_2 can be attained and its molecular flow regime can be extended from high vacuum up to 1000 mbar (*i.e.*, the conductance in molecular flow C_{SLE} is independent of inlet pressure P_{CDG} and depends on only temperature, the molecular mass of a test gas and the geometric structure of the micro-hole). **Figure 3** indicates a strong dependence of the conductance values on the inverse square root of the molecular mass for all these test gases, according to which one can readily calculate the conductance for any non-condensable gas once one conductance value of these gases is known.

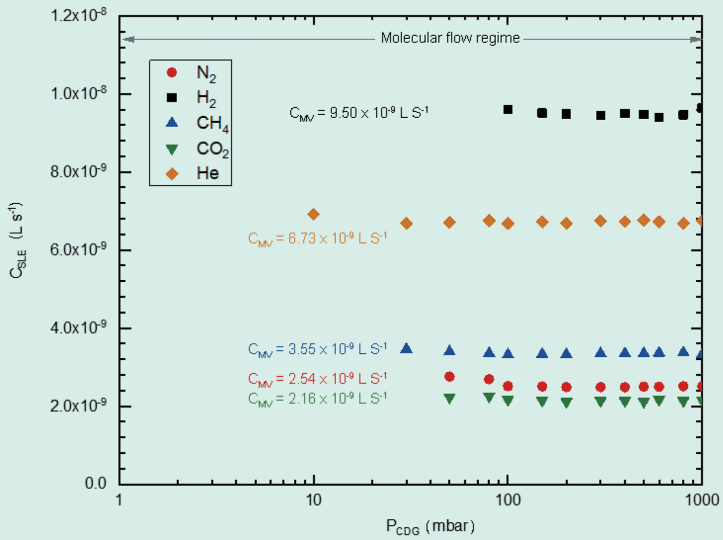

Fig. 2: Conductance of a SLE as a function of inlet pressure for various non-condensable gases.

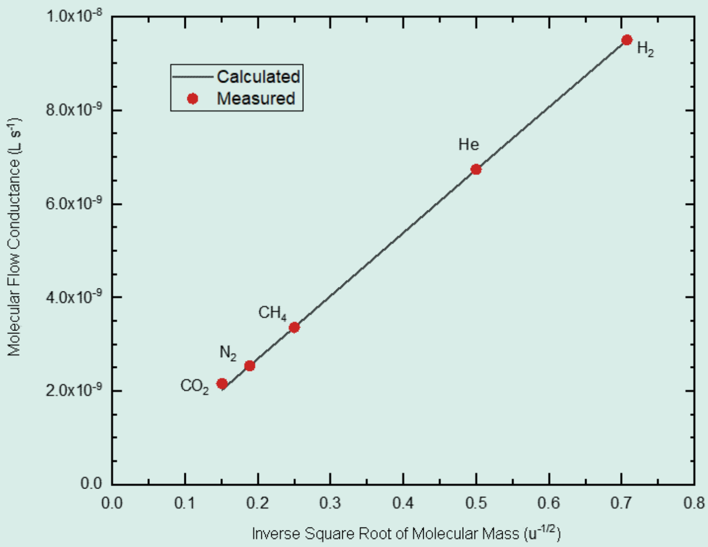

Fig. 3: Dependence of molecular flow conductance on the gas molecular mass.

As mentioned above, the standard leak element can be used to calibrate in situ an ionization gauge; **Fig. 4** shows the relative sensitivity factors of an extractor gauge measured with the conductance modulation method.[1] The relative sensitivity factors for N_2, H_2, CH_4, CO_2 and He are 1.00, 0.45, 0.37, 1.38 and 0.18 respectively; these measured values coincide closely with the data of previous studies.

In summary, we demonstrated the feasibility of using femtosecond laser micromachining to create a novel standard leak element, of which the molecular flow conductance for nitrogen can be achieved as small as 2×10^{-9} L s^{-1}. (Reported by Che-Kai Chan)

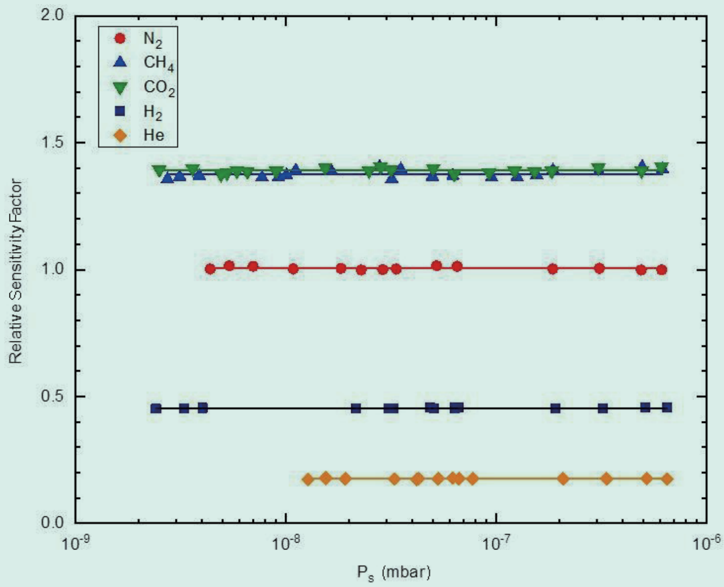

Fig. 4: Relative sensitivity factor *f* of an extractor ionization gauge for N_2 (*f* = 1.00), H_2 (*f* = 0.45), CH_4 (*f* = 1.37), CO_2 (*f* = 1.38) and He (*f* = 0.18). [Reproduced from Ref. 2]

References

1. C.-K. Chan, C.-Y. Tu, S.-D. Yeh, C.-C. Chang, T.-C. Lin, C.-W. Luo, C.-S. Hwang, Vacuum **180**, 109650 (2020).
2. C.-K. Chan, S.-D. Yeh, C.-C. Chang, C.-Y. Tu, I.-C. Yang, K.-L. Chang, C.-W. Luo, C.-S. Hwang, Vacuum **184**, 109945 (2021).

Conceptual Design of TPS Phase-III Beamlines

The third phase of the Taiwan Photon Source (TPS) beamline project is officially launched in 2021. This third phase of the beamline construction project includes five insertion devices and four bending magnets, for nine beamlines in total. Of these nine beamlines, three are soft X-ray beamlines, one is a tender beamline and the other five are hard X-ray beamlines. The primary object of the third-phase beamline is to move the beamline of the current Taiwan Light Source (TLS) to TPS, and also serve users and provide the most updated technology. The third beamline project includes the following beamlines:

1. **TPS 11A** In-situ Serial Protein Crystallography Beamline
2. **TPS 14A** Small-angle X-ray Scattering Beamline
3. **TPS 20A** Two Dimensional X-ray Diffraction Beamline
4. **TPS 32A** Tender X-ray Absorption Spectroscopy Beamline
5. **TPS 33A** Dragon Beamline
6. **TPS 35A** Soft X-ray Absorption Spectroscopy Beamline
7. **TPS 38A** X-ray Absorption Spectroscopy Beamline
8. **TPS 43A** Ambient Pressure X-ray Photoelectron Spectroscopy Beamline
9. **TPS 47A** High-resolution X-ray Absorption Spectroscopy Beamline

The current construction schedule of the third phase of the TPS beamlines is shown in **Fig. 1**. The planned schedule is from 2021 to 2026; the construction of these nine beamlines is estimated to take six years. The floor map of the TPS beamline is presented in **Fig. 2**.

The main purpose of the third phase of the beamlines is to relocate the beamlines of the current TLS and to continue to develop and to achieve the most important scientific topics. It contains more challenging protein crystallography (PX) on site, mainly for proteins that cannot be successfully resolved at present. The other eight beamlines include small-angle scattering, powder diffraction, dragon beamline, X-ray absorption spectrum, soft X-ray absorption spectrum, chamber pressure/vacuum photoelectron spectroscopy, soft X-ray absorption spectrum, *etc.*; all are transferred from the current TLS. The functions of these eight beamlines in operation is expected to replace the scientific research and development capabilities of TLS in the shortest time. At the time of writing, a report of most conceptual design of these beamlines is finished, as introduced in the following paragraphs.