Development and Application of VUV/UV Light Sources and Lasers ◇

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Electron beam excited VUV/UV light sources and lasers are developed in a research project funded by the Bayerische Forschungsstiftung (Project 482/01). Light source development and operation of a He-Ne-Ar laser (neon line at 585 nm) has been described in a previous report [1]. Briefly, the project is based on a technology which uses very thin (300 nm) silicon nitride membranes to send low energy (typ. 12 keV) electron beams into dense gases. Membranes of 0.5 mm^2 (0.7mm × 0.7 mm) and 28 mm^2 (0.7 mm × 40 mm) are routinely used. An average beam power of 0.5 W/mm^2 can be sent through the foils and 5 mJ/mm^2 can be transported through the membrane in the pulsed mode, respectively. The electron beam power or pulse energy is deposited in the gas leading to excitation and subsequent light emission. Formation and radiative decay of excimer meolecules is an important process for light emission from the sources under study.

In the year 2005 experiments for a UV- KrF laser have been prepared using a 5 A electron gun developed by THALES company and recombination processes in neon have been measured for neon with the 2 A electron gun described in ref. [1]. Studies which have been performed in 2005 on the gas kinetics of Ne-H_2 light sources emitting the Lyman-a line at 121.6 nm as well as measurements and model calculations on the spatial distribution of light emission from low energy electron beam excited targets are described in separate contributions to this report.

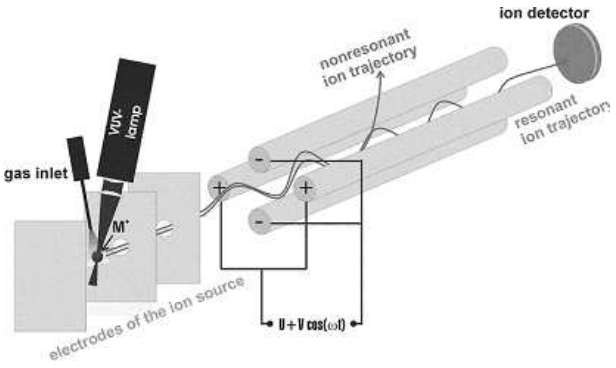

Fig. 1: Schematic drawing of a QMS-system with the electron-beam pumped VUV lamp.

The incoherent VUV light sources described in ref. [1] were used by the GSF research group for analytical chemistry, detecting organic molecules with the method of S(ingle) P(photon) I(onization). An advantage of this technique is that the analyte molecules are not destroyed by the ionization process. Photons with typically 10 eV energy are well suited to ionize and sensitively detect molecules which are relevant e.g. for environmental monitoring or medical testing.

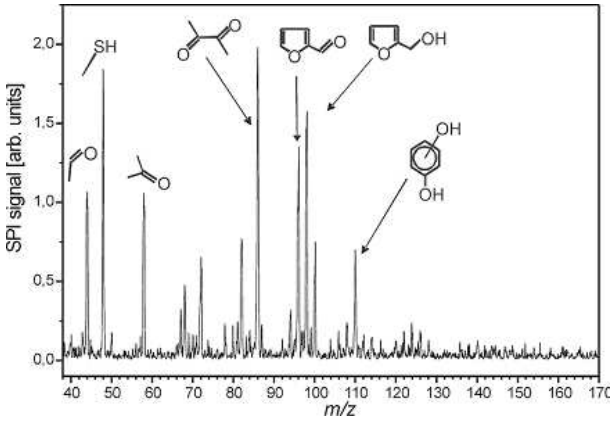

Fig. 2: SPI-QMS spectrum of coffee headspace gas obtained by scanning with 1 amu/s.

The novel electron beam pumped VUV light sources have the advantages, for example in comparison with frequency multiplied lasers which are alternatively used for SPI, that they are compact, low cost and require no delicate alignment. The incoherent VUV sources have been used for SPI ion sources in both quadrupole (QMS, Fig. 1) and time-of-flight mass spectrometers (TOFMS, Fig. 3) [2,3,4]. The rugged and compact mass spectrometers were characterized and tested with standard gas mixtures and subsequently applied to the analysis of several gases. Detection limits in the low ppb region were achieved. The recently developed systems are also well suited for industrial research applications or quality control purposes.

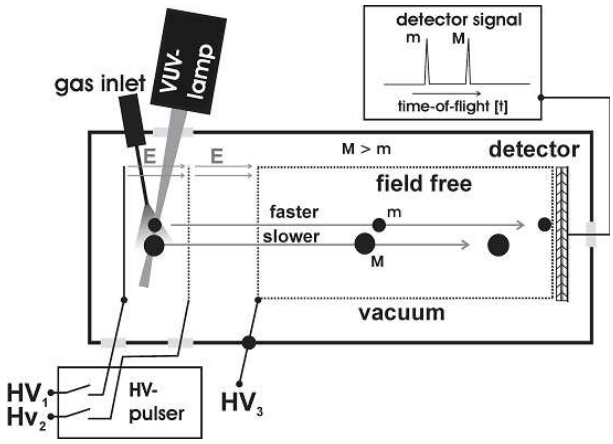

Fig. 3: Schematic drawing of a TOFMS-system with the electron-beam pumped VUV lamp

◇ The authors acknowledge funding by Bayerische Forschungsstiftung, DFG, and MLL

A schematic drawing of the QMS system with an argon excimer VUV lamp (center wavelength 126 nm, 9.8 eV) is shown in Fig. 1. A mass spectrum of the complex headspace gas from heated coffee powder is shown in Fig. 2. Due to the soft ionization of the trace compounds and information about the composition gathered by off-line methods the peaks of the mass spectrum could be identified. In food industry monitoring of some selected substances that are related to the roasting degree of coffee can help to control the roasting process and therefore ensure a constant quality.

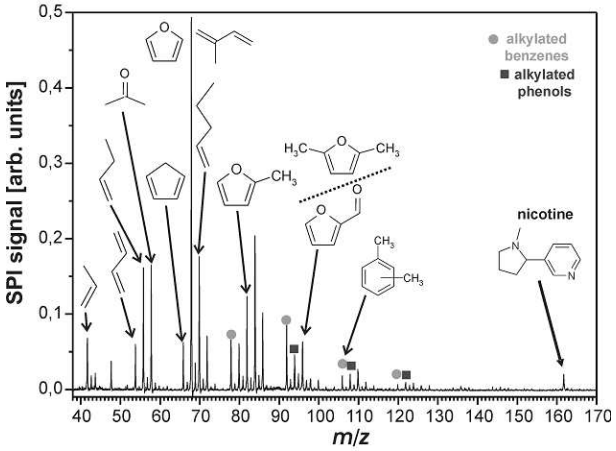

Fig. 4: SPI-TOFMS spectrum of mainstream cigarette smoke obtained by averaging 130 consecutive single spectra (generated with 50 Hz), thus covering one single puff.

A time of flight mass spectrometer system was used to analyse cigarette smoke (Fig. 4). The setup is perfectly suited to analyse such fast changing, complex process-gas because the continuous measurements at 50 Hz provide detailed information about pyrolysis and combustion processes inside the burning cigarette.

References

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