Spectroscopy of a miniature spark discharge in the range of 40 - 1200 nm

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Introduction
At the conference of the American society for mass spectrometry (ASMS) in 2011 our group introduced a photoionization source, which employs a spark discharge lamp mounted windowless on a custom glass transfer capillary of an API mass spectrometer [1]. The hollow electrode assembly is supplied with a continuous gas flow at one electrode, and actively pumped at the counter electrode. The discharge gap is < 1 mm. A small circuit board with a high-repetitive capacitor charger provides up to 1.5 kV with a repetition rate of 15 kHz and an output capacity of 2 nF. Operation of the spark discharge design has proven to be temporally, as well as spatially highly stable and reproducible.

Accordingly, this plasma drew our attention to general, systematic investigations on the prevailing plasma chemistry. A setup was designed to operate, investigate and correlate the VUV to NIR emission, the current/voltage profile and the electron emission of the discharge under well defined conditions.

Methods
Discharge
- main gas flow of helium (150 mL/min)
- admixture of N₂, O₂, He and Ar (1 mL/min)
- power supply: custom designed DD20_10 (Hartmann & Braun, Germany)

Spectrometer
- VUV: Acton 3020 VUV spectrometer (Acton Research Corporation, Acton, MA, USA), modified for operation with helium at atmospheric pressure (counter helium flow of 50 mL/min through the entrance slit)
- scintillator-coated lens with NaI scintillate (custom made via pass-solution)
- Photomultiplier tube, R928, Hamamatsu Photonics, K.K., Hamamatsu City, Japan
- A/D converter: R332-AOC16/24, Iktis GmbH, Berlin, Germany
- custom software (VB 2010 Express)
- UV-NIR: AvaSpec-3648 (Avantes BV, Eerbeek, The Netherlands)

Oscilloscope
- RTE 1014, R&S, Cologne, Germany

Results
Helium discharge with varying mixing ratios of additives. Exemplarily shown are VUV, UV/VIS/NIR spectra of "pure" helium and with 2.3 ppm V O₂ at 1014 mbar. Spectra a-e are close ups from the UV/VIS/NIR regime with increased integration time.

Conclusions & Outlook
For every experimental condition the presented setup provides a reproducible dataset of:
- VUV spectra with selectable integration times and
- current/voltage profiles of the breakdown, from which essential parameters such as the electron density can be derived.

Outlook:
- establishing a systematic database of VUV and UV/VIS/NIR spectra for different discharge gas compositions and correlated them
- time resolved VUV and UV/VIS/NIR emission spectroscopy
- use the generated data to gain deeper insight into the mechanisms of the discharge process

Literature

Acknowledgement
Financial support from the German Research Foundation within project KE 1816/1-1 is gratefully acknowledged. Many thanks to Prof. Dr. Jan Benedikt for providing literature.