Extreme Ultraviolet Source at 40 nm with Alkali Metal Vapor for Surface Morphology Applications

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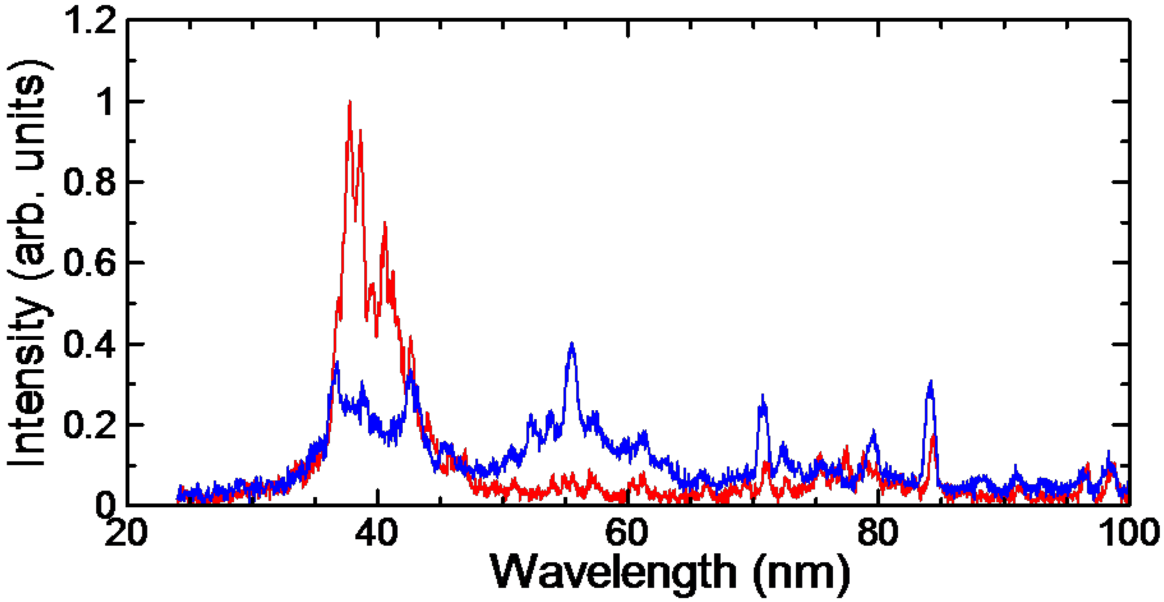
University College Dublin, Belfield, Dublin 4, Ireland
Sunday 14 November, 2010, 4:30 PM – 6:00 PM

What's new

- Observation of the spectra of a potassium plasma
- Evaluation of the multiple charge state ions
- Discussion of the possibility of the hollow cathode mode



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Characteristics of extreme ultraviolet emission from a discharge-produced potassium plasma for surface morphology application

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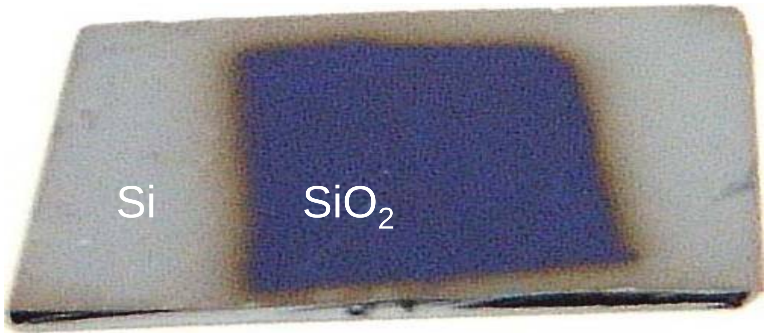
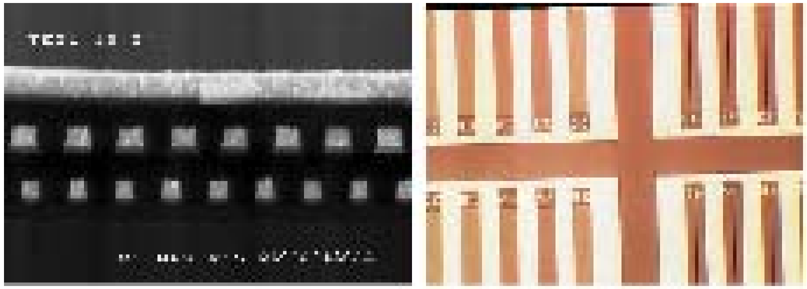
We have demonstrated a discharge-produced microplasma extreme ultraviolet source based on a pure potassium vapor. Potassium ions produced strong broadband emission around 40 nm with a bandwidth of 8 nm (full width at half-maximum). The current-voltage characteristics of microdischarge suggest that the source operates in a hollow cathode mode. By comparison with atomic structure calculations, the broadband emission is found to be primarily due to $3d-3p$ transitions in potassium ions ranging from K^{2+} to K^{4+}.

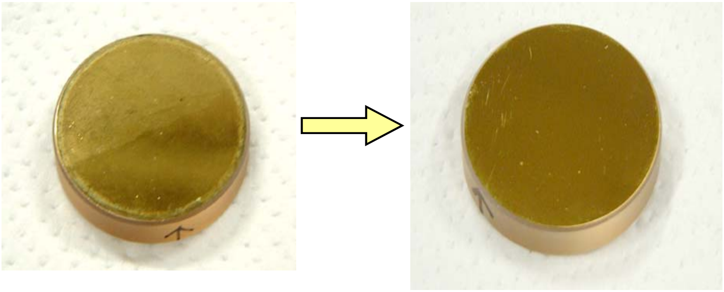
Applications by us



Remove SiO_2 layer

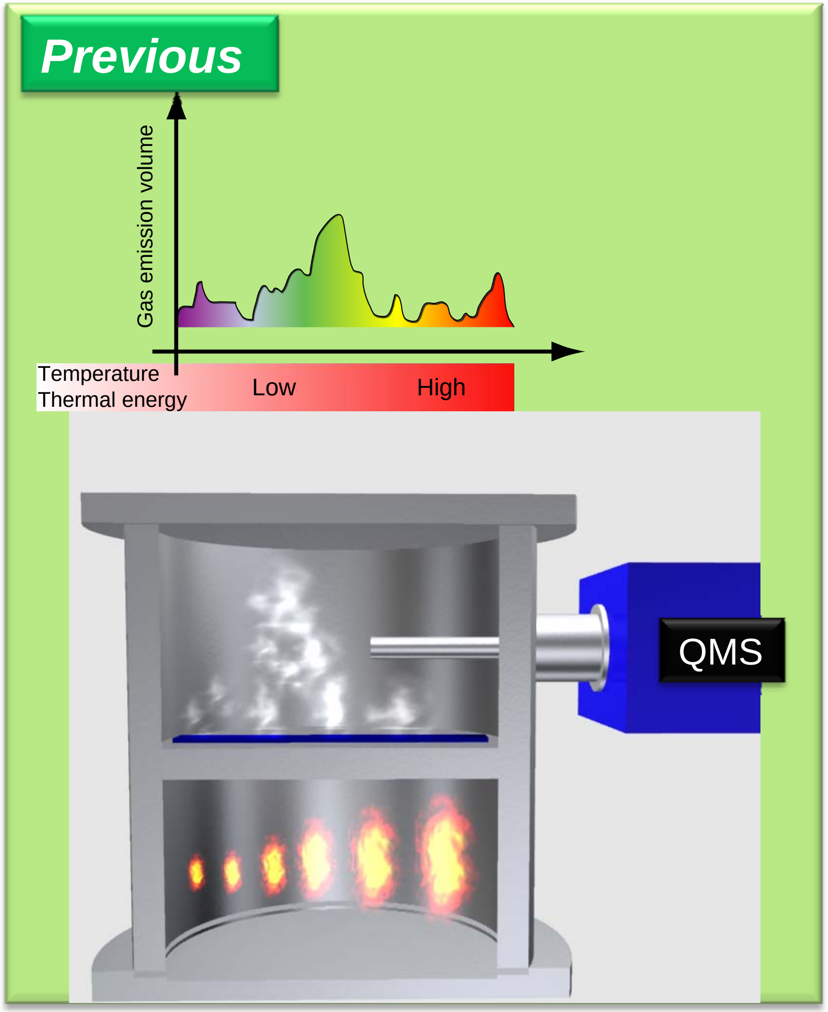


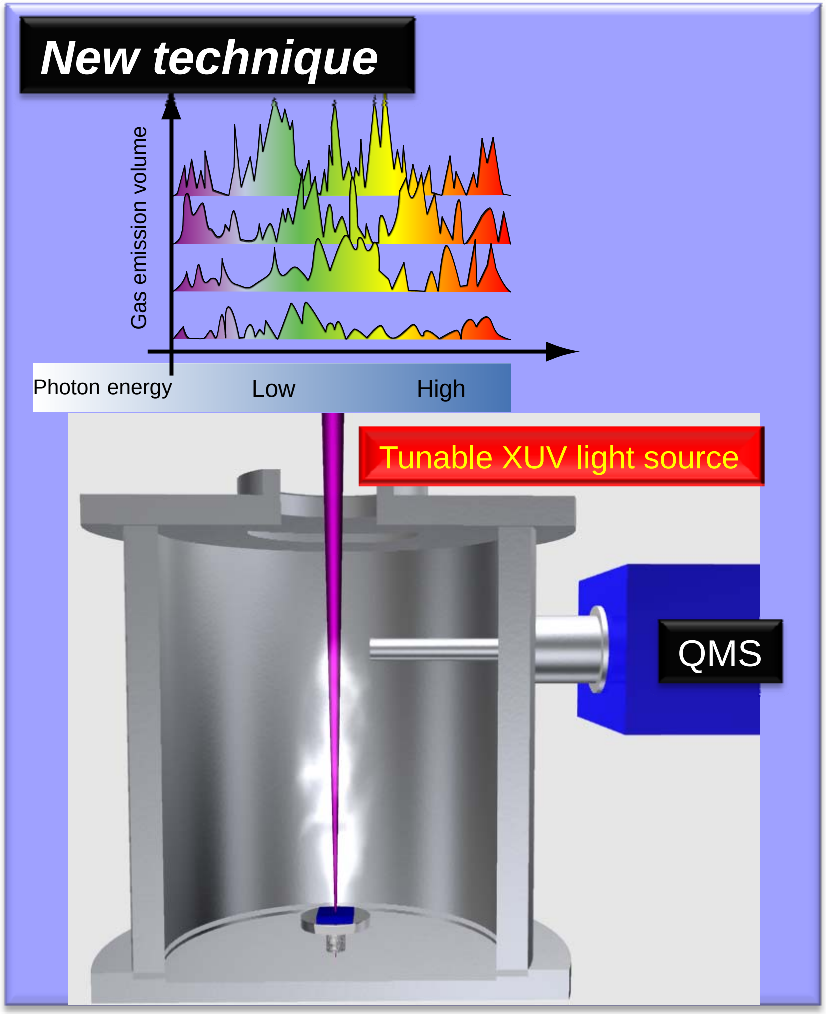
VUV CVD



Cleaning of the grating

Photo-stimulated desorption mass spectrometer using EUV emission

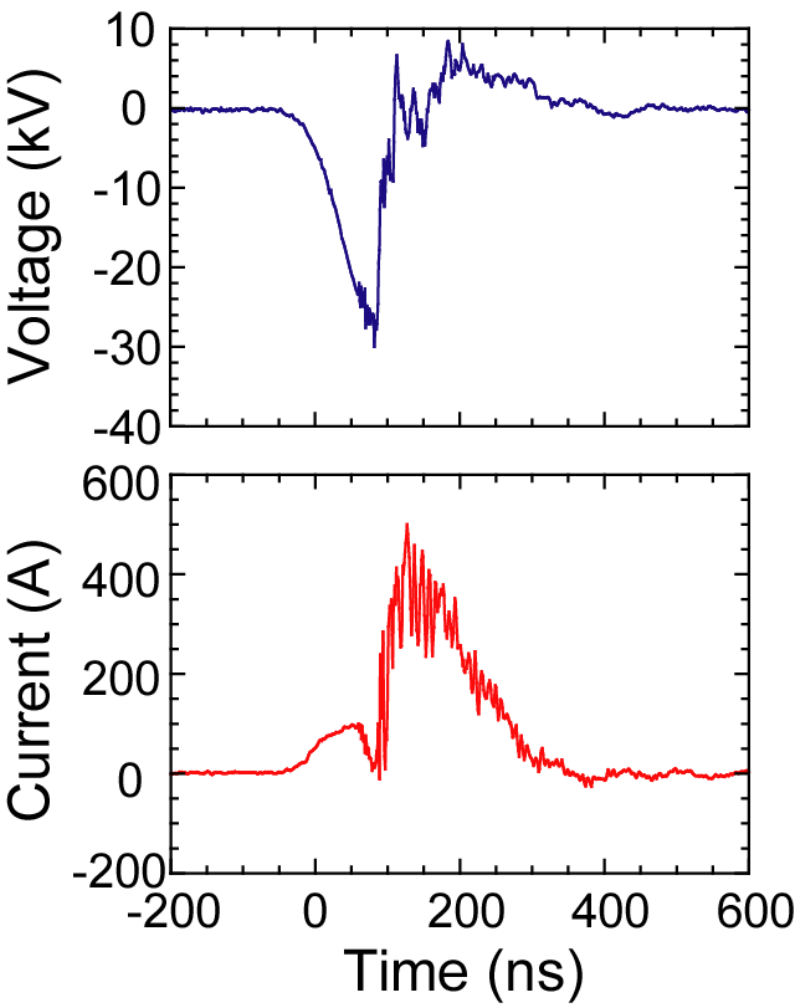


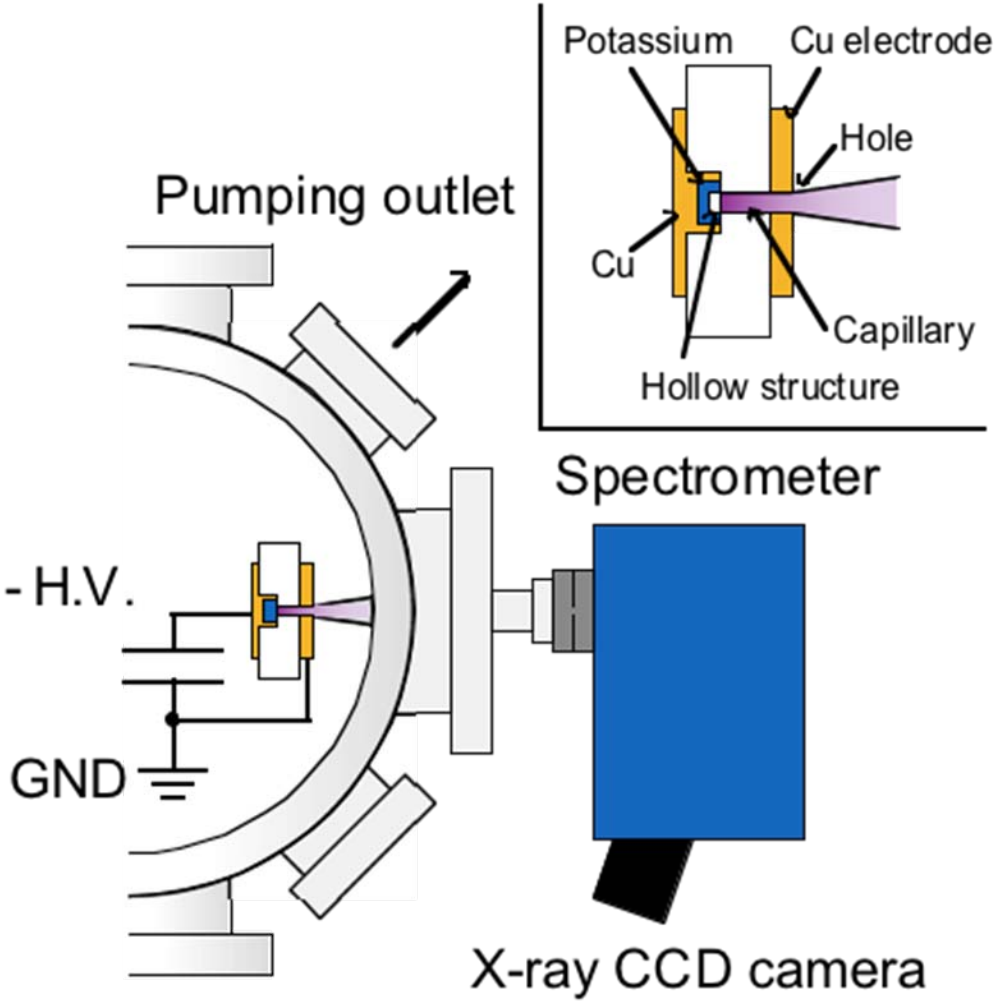


Objective

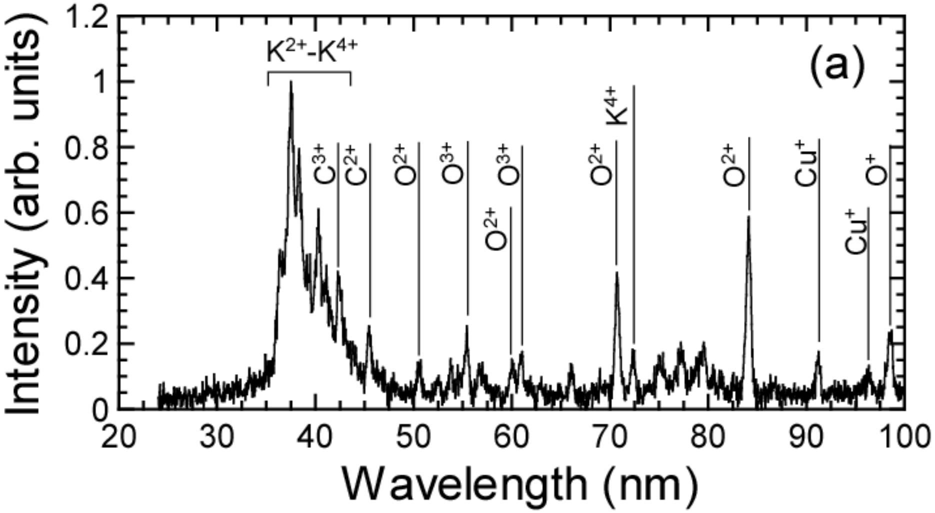
We characterize the capillary discharge-produced plasma XUV source by use of pure alkali metal vapor.

Schematic diagram of the experimental apparatus

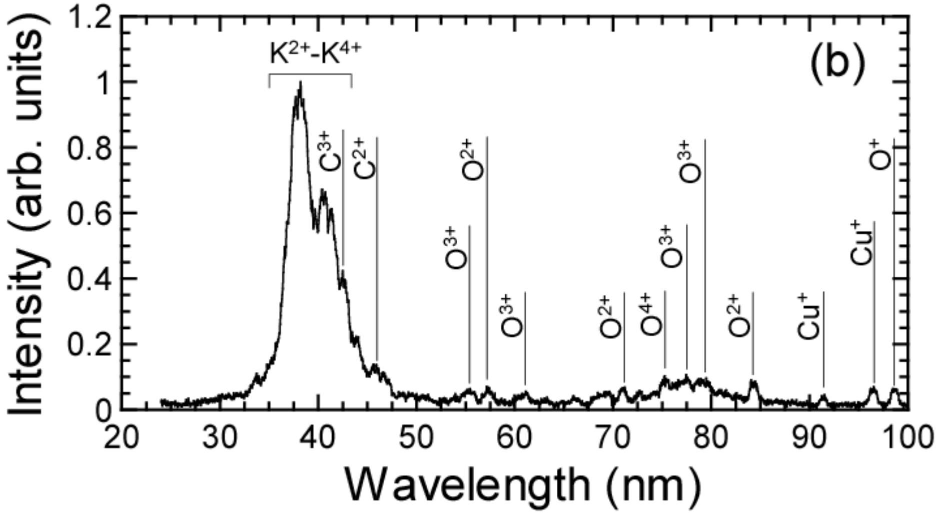




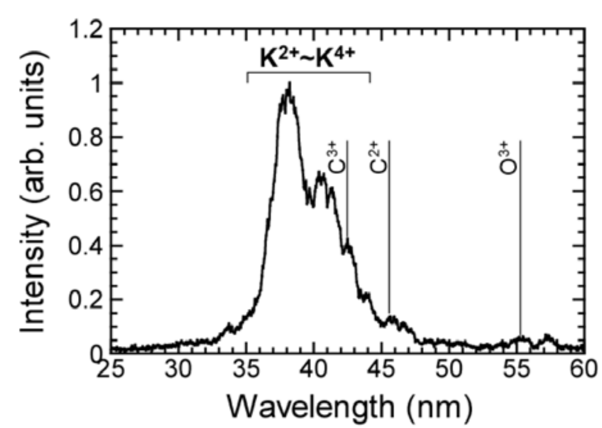
Emission spectra from the different capillary inner diameters



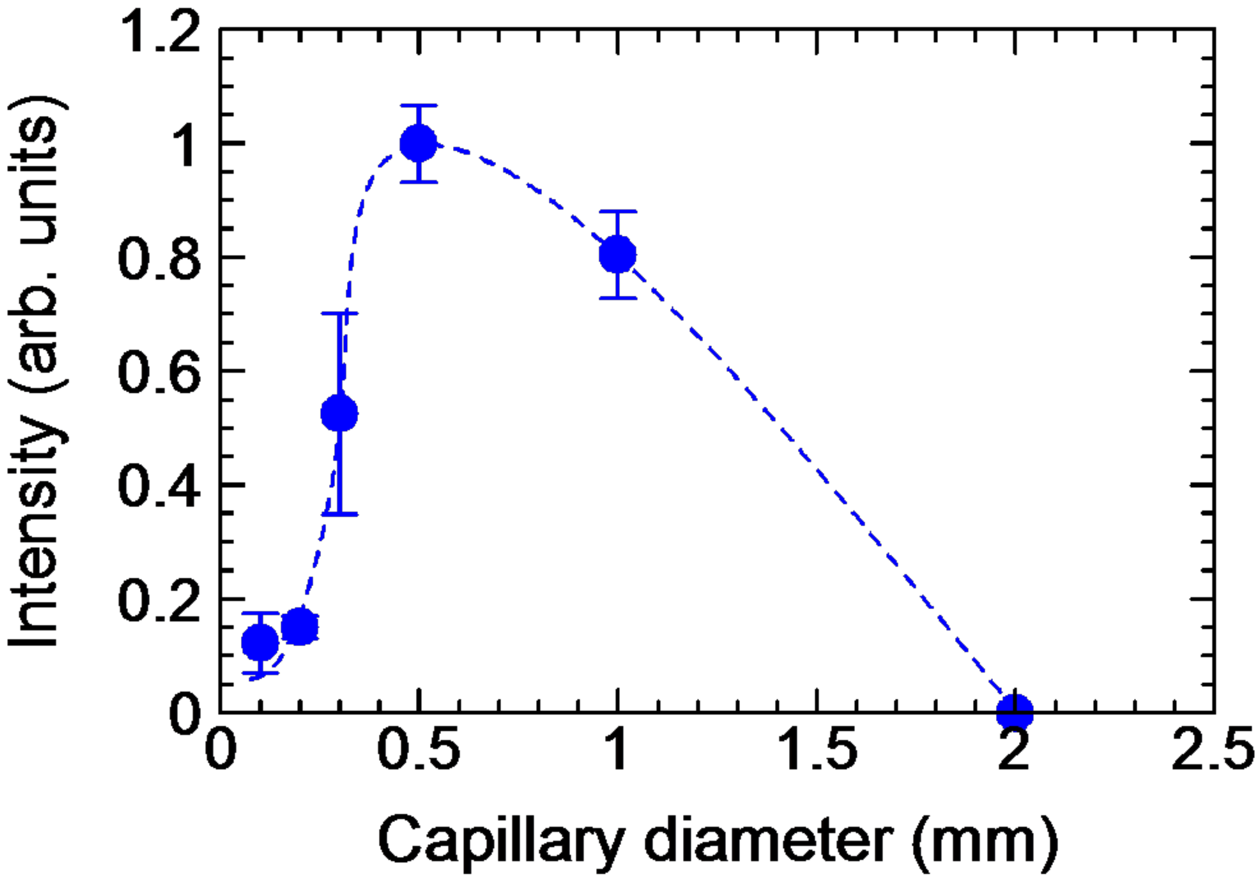
(a) Inner diameter: 1 mm



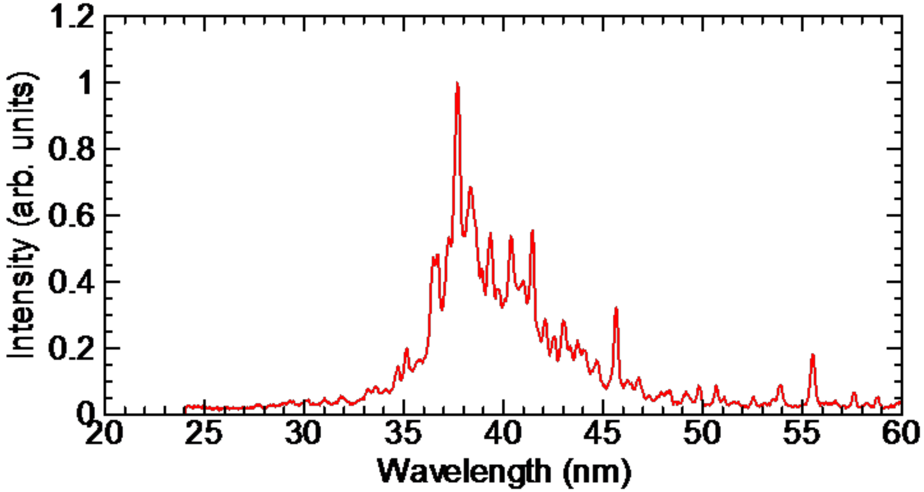
(b) Inner diameter: 0.5 mm



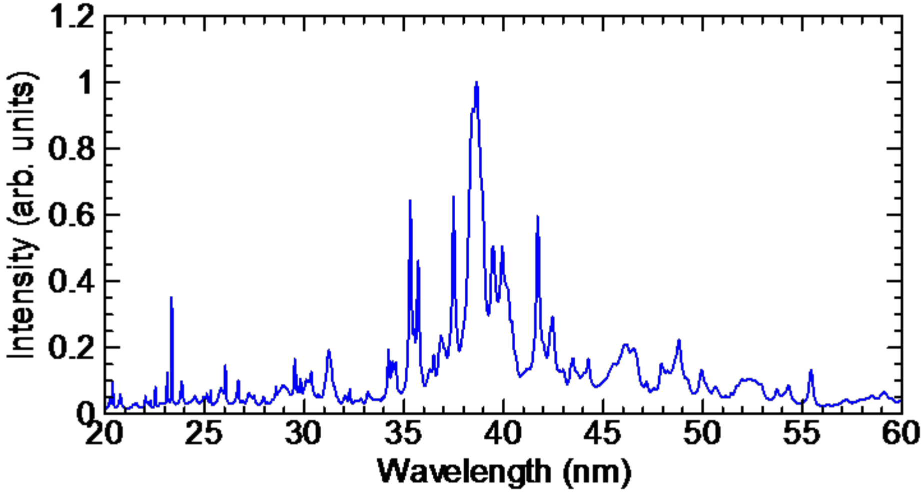
Capillary inner diameter dependence of the emission energy



Comparison of experiments and numerical simulation

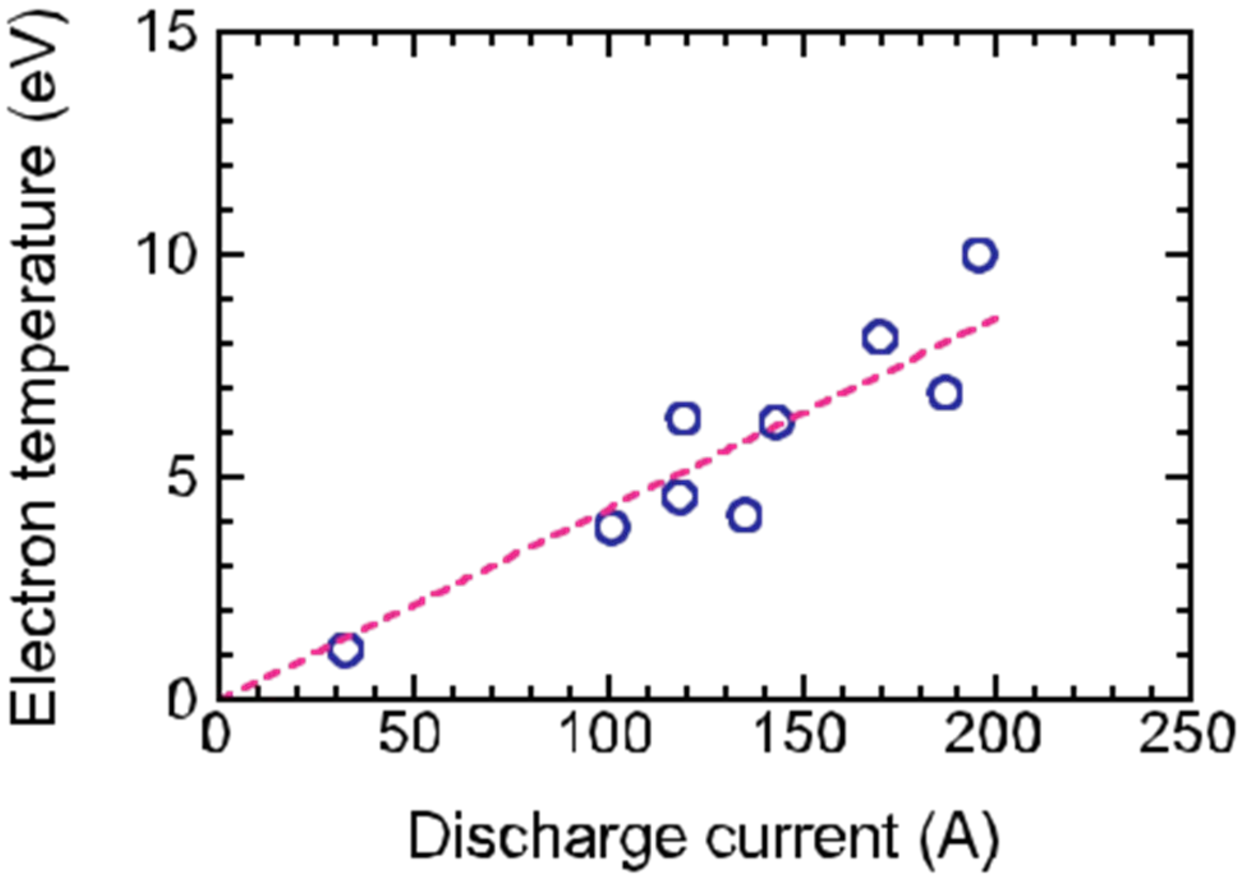


(a) Experiments



(b) Numerical simulation

Discharge current dependence of time-integrated electron temperature

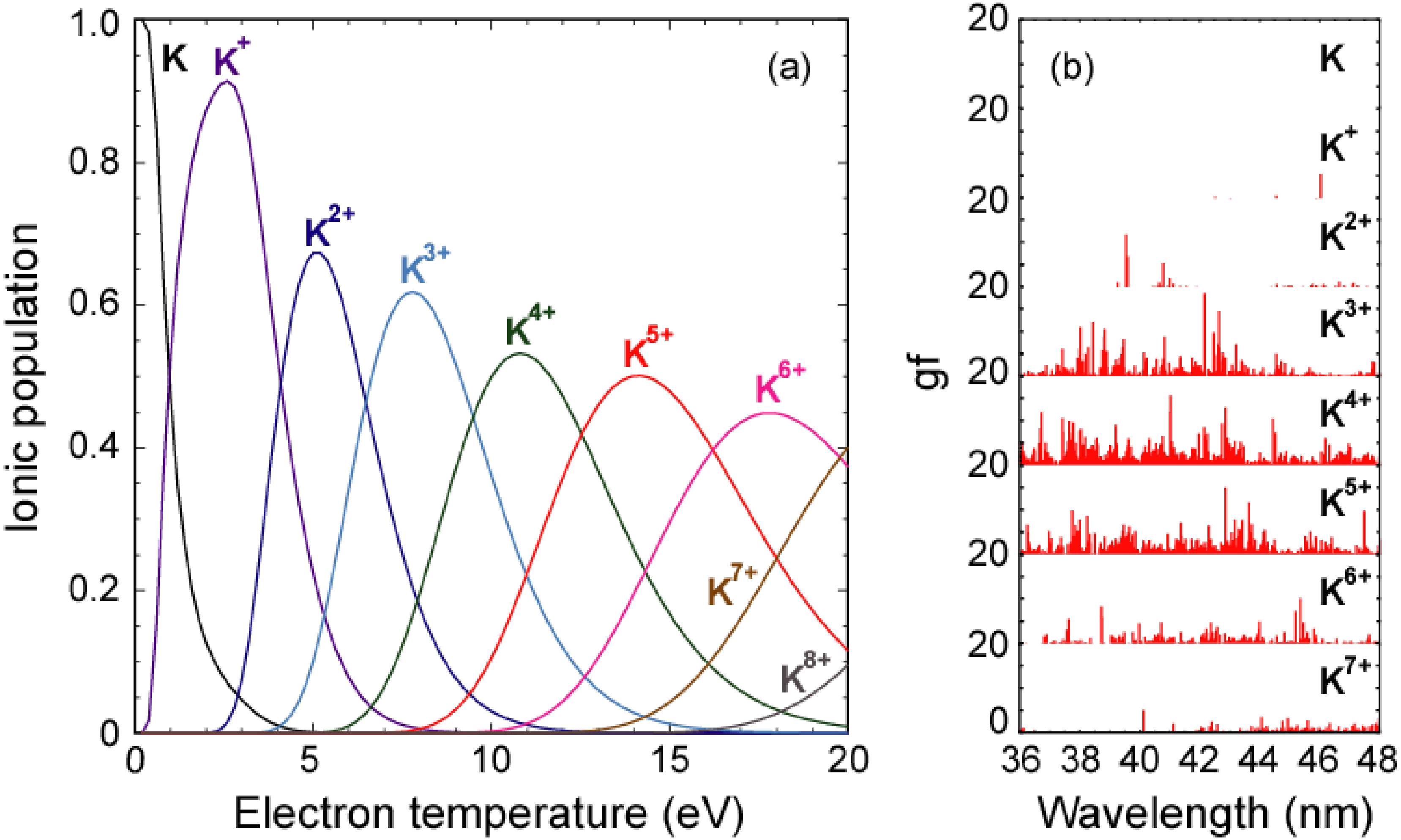


$$T_e \propto \frac{\Delta E}{\ln(I_1\lambda_1/I_2\lambda_2)}$$

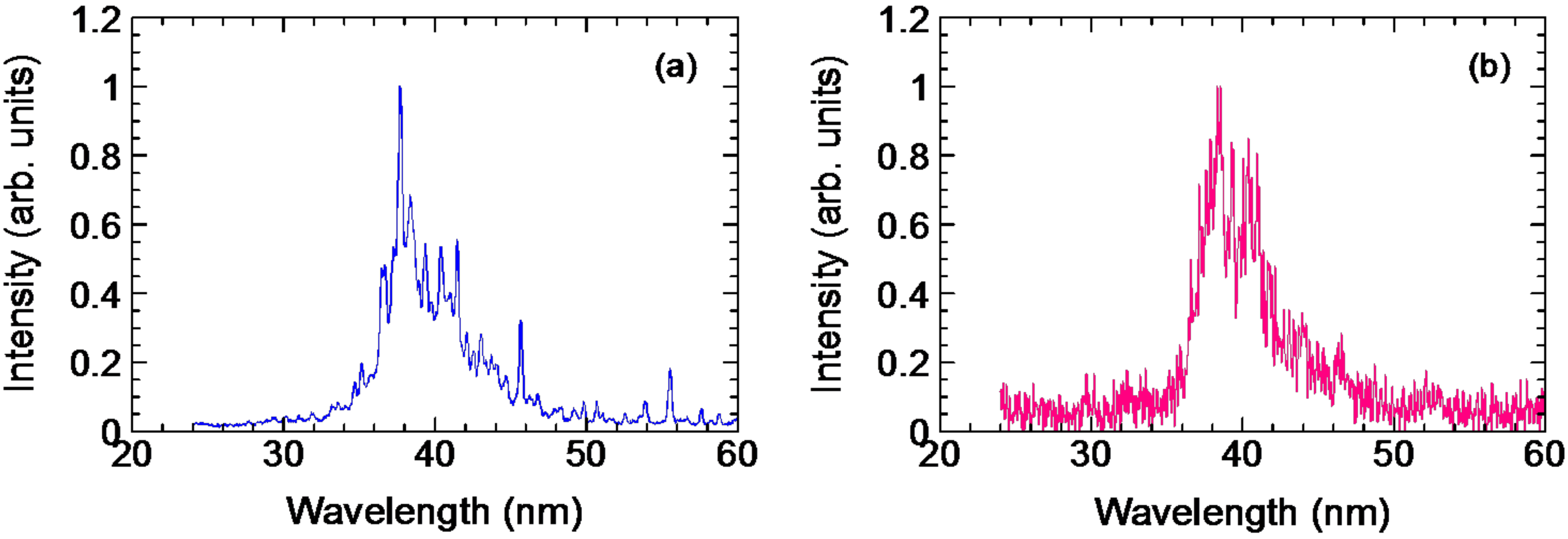
O^{2+}: λ_1 = 70.4 nm
O^{2+}: λ_2 = 83.4 nm

O^{3+}: λ_1 = 55.4 nm
O^{3+}: λ_2 = 61.7 nm

Ion population of multi-charged potassium ions

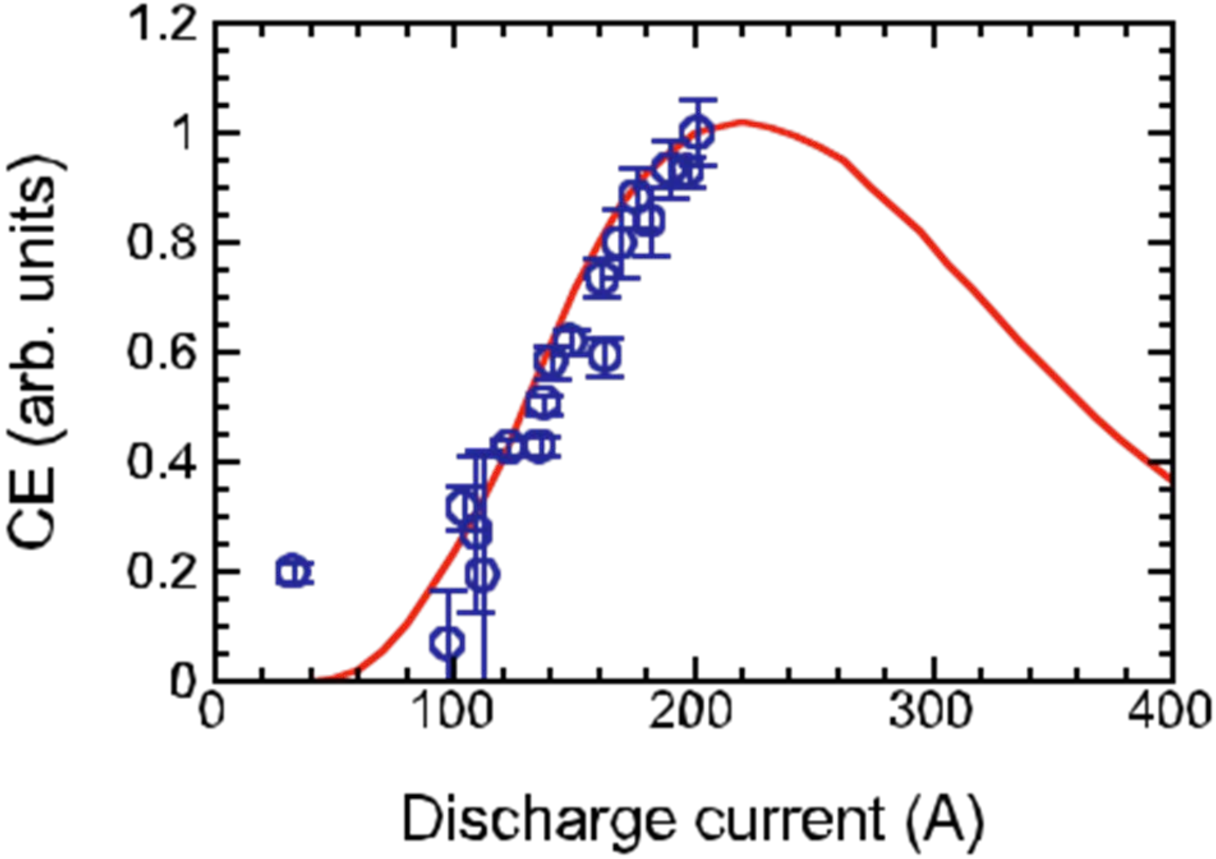


Comparison between DPP and LPP at electron temperature of 12 eV

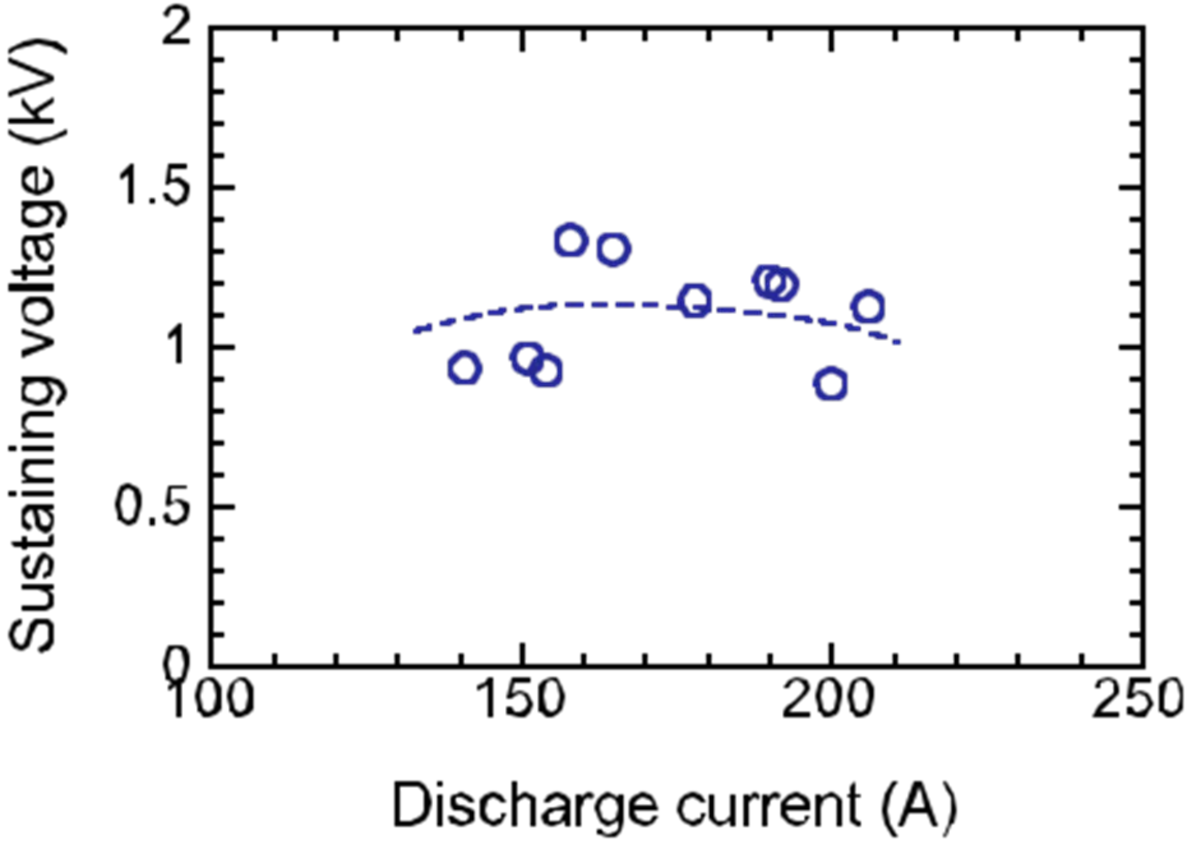


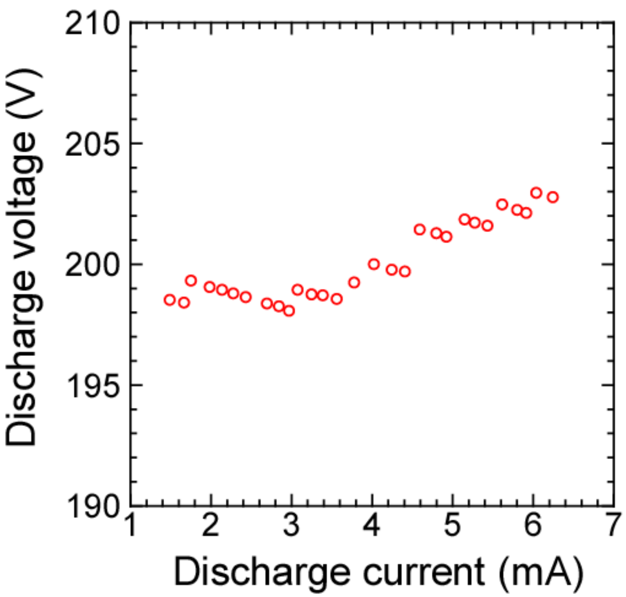
Time-integrated spectra from a capillary discharge-produced plasma (a) and from a Nd:YAG laser-produced plasma (b) at the laser intensity of 2×10^{10} W/cm^2 with a focal spot size of 250 μm (FWHM).

Discharge current dependence of the XUV conversion efficiency



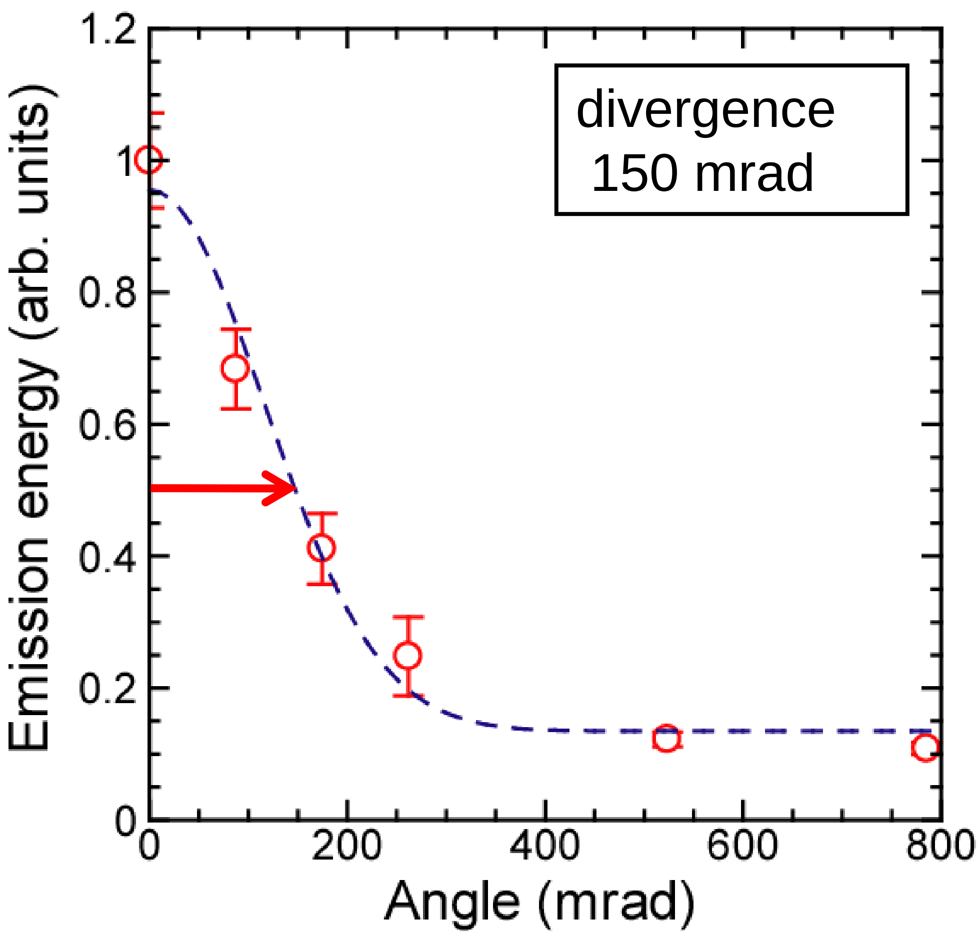
I-V dependence:
Possibility of hollow cathode mode

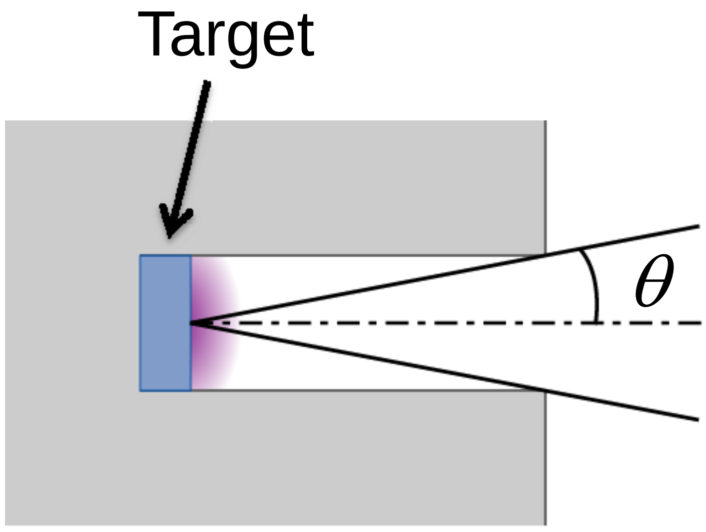




A. El-Habachi *et al.*,
APL. **72**, 22 (1998).

Angular distribution of the XUV emission energy





$$\theta = \tan^{-1}\frac{r}{l}$$

□ 170 mrad

Summary

We have developed and observed the compact discharge-produced plasma XUV source at 40 nm.

- ➔ We have characterized the emission spectra of a potassium plasma.
- ➔ We have evaluated the multiple charge state ions using the collisional-radiative (CR) model.
- ➔ We have discussed the possibility of the hollow cathode mode in a capillary discharge-produced potassium plasma.