Supplementary Information

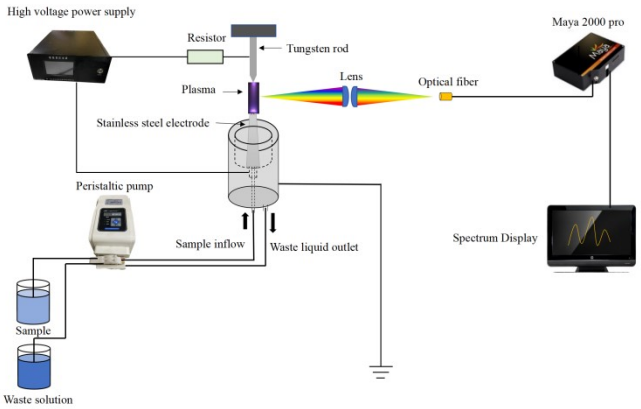
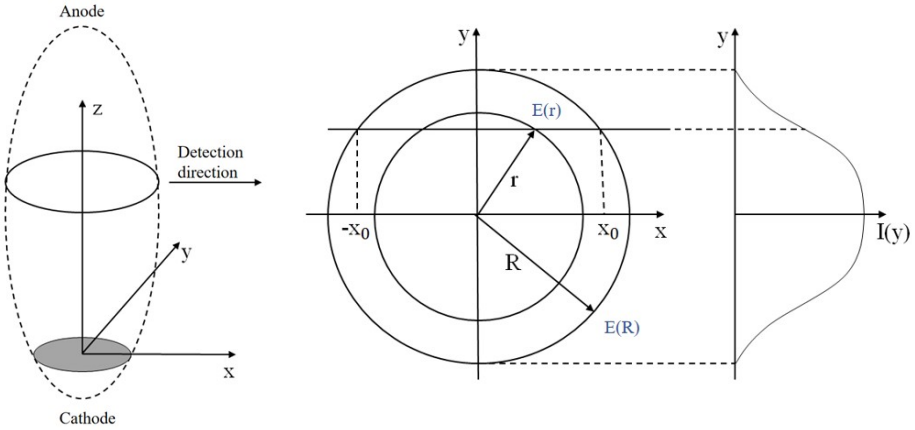


Fig. 1 Schematic diagram of the SCGD system.



(a) (b)

Fig. 2 Geometrical interpretation of the Abel transform in a cylindrically symmetric plasma. (a)Cylindrical symmetric plasma, (b)Transverse intensity.

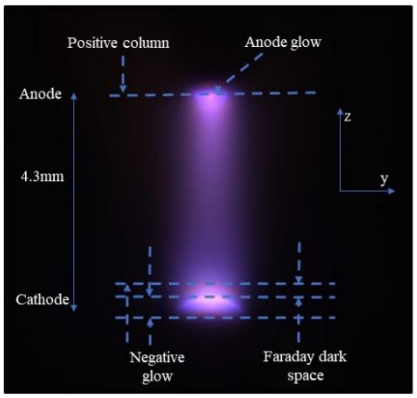


Fig. 3 SCGD photographs after ignition on the surface. Conditions: supporting electrolyte: HNO_3, solution pH: 1.0, discharge current: 70 mA, and flow rate: 2.92 mL min^{-1}.

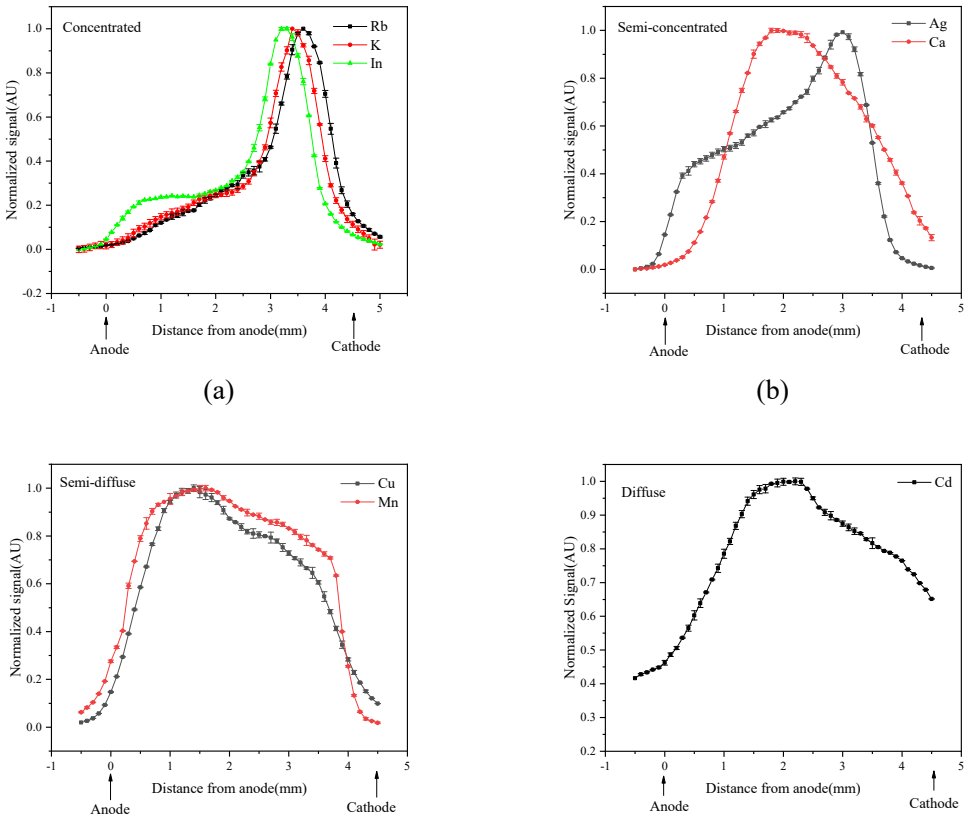
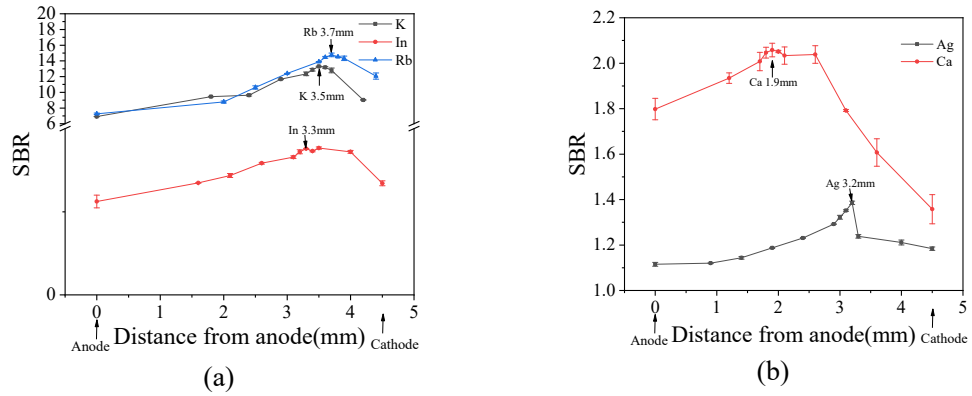


Fig. 4 Vertical spectral signal maps for several elements categorized as (a)concentrated, (b)semi-concentrated, (c)semi-diffuse, or (d)diffuse, depending on the profile structure. Conditions: 1 mg per L Rb, 0.5 mg per L K, 2 mg per L In, 2 mg per L Ag, 5 mg per L Ca, 2 mg per L Cu, 3 mg per L Mn, 2.5 mg per L Cd, supporting electrolyte: HNO_3, solution pH: 1.0, discharge current: 70 mA, and flow rate: 2.92 mL min^{-1}.



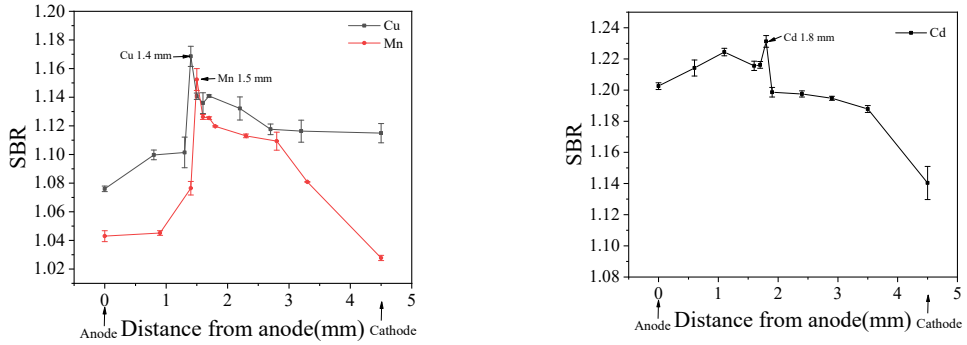


Fig. 5 Vertical comparison SBR maps for several elements categorized as (a)concentrated, (b)semi-concentrated, (c)semi-diffuse, or (d)diffuse, depending on the profile structure. Conditions: 1 mg per L Rb, 0.5 mg per L K, 2 mg per L In, 2 mg per L Ag, 5 mg per L Ca, 2 mg per L Cu, 3 mg per L Mn, 2.5 mg per L Cd, supporting electrolyte: HNO_3, solution pH: 1.0, discharge current: 70 mA, and flow rate: 2.92 mL min^{-1}.

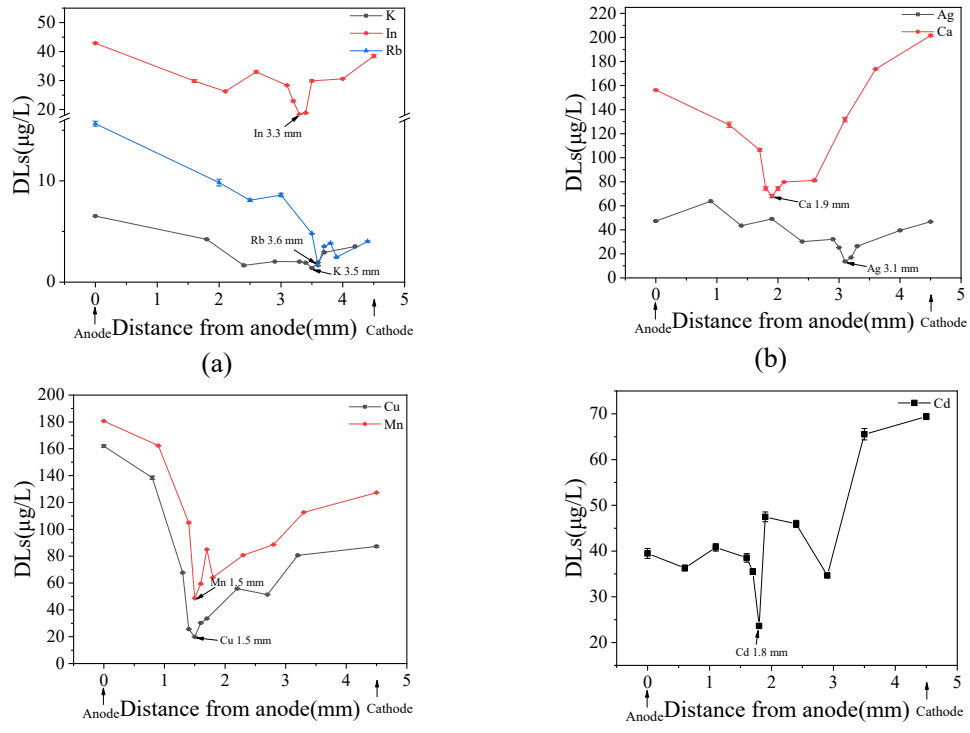
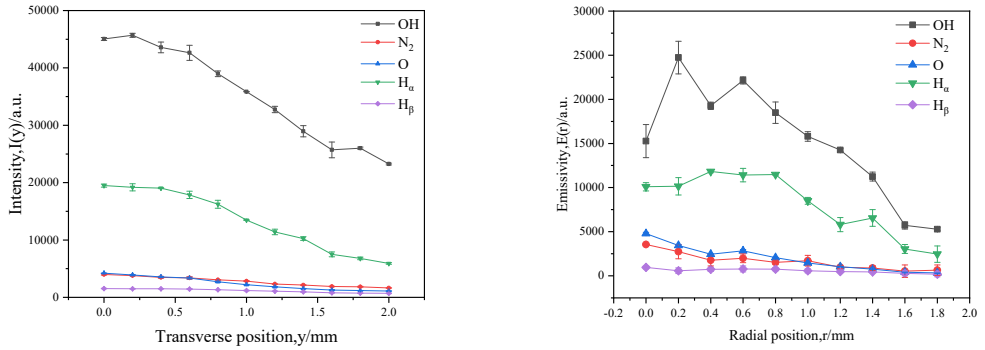


Fig. 6 Vertical comparison DLs maps for several elements categorized as (a)concentrated, (b)semi-concentrated, (c)semi-diffuse, or (d)diffuse, depending on the profile structure. Conditions: 1 mg per L Rb, 0.5 mg per L K, 2 mg per L In, 2 mg per L Ag, 5 mg per L Ca, 2 mg per L Cu, 3 mg per L Mn, 2.5 mg per L Cd, supporting electrolyte: HNO_3, solution pH: 1.0, discharge current: 70 mA, and flow rate: 2.92 mL min^{-1}.



(a) (b)

Fig. 7 Spectral intensity of main species in blank solution before and after Abel inversion; (a) Single-sided lateral distribution of spectral intensity; (b) Radial distribution of emissivity after Abel inversion. Conditions: supporting electrolyte: HNO_3, solution pH: 1.0, discharge current: 70 mA, and flow rate: 2.92 mL min^{-1}.

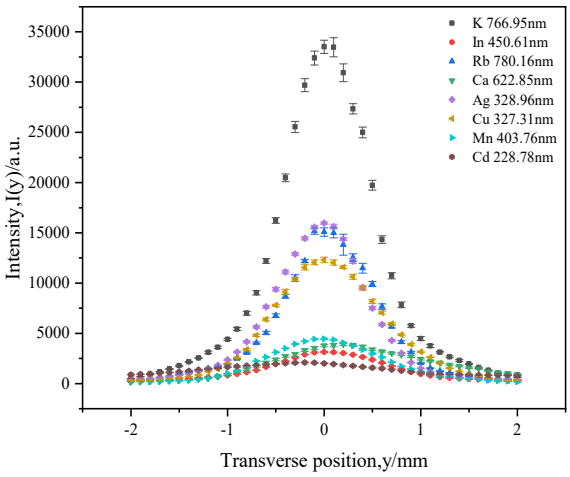
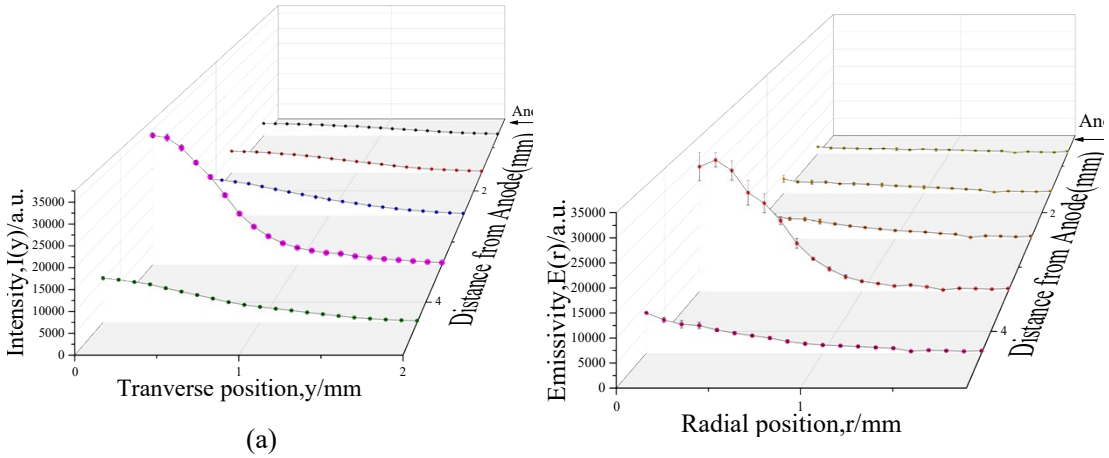
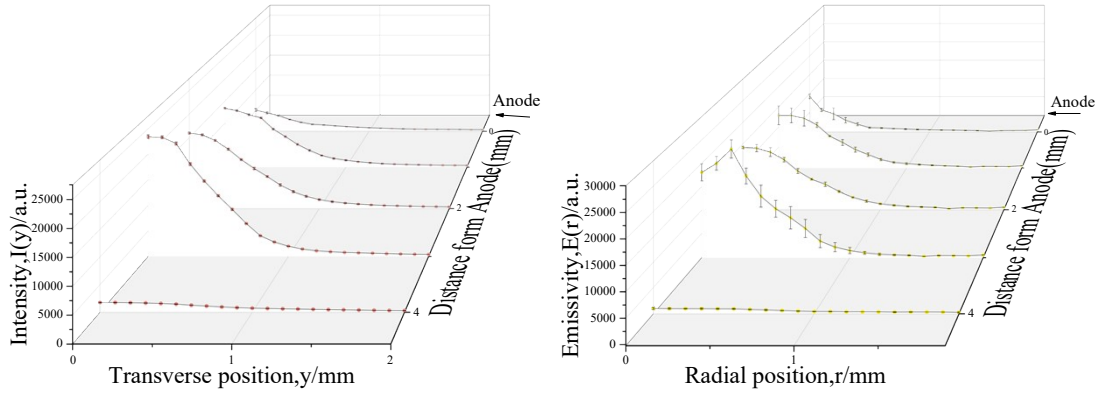


Fig. 8 Lateral distribution of spectral intensity of metal elements along the y-axis. Conditions: 1 mg per L Rb, 0.5 mg per L K, 2 mg per L In, 2 mg per L Ag, 5 mg per L Ca, 2 mg per L Cu, 3 mg per L Mn, 2.5 mg per L Cd, supporting electrolyte: HNO_3, solution pH: 1.0, discharge current: 70 mA, and flow rate: 2.92 mL min^{-1}.



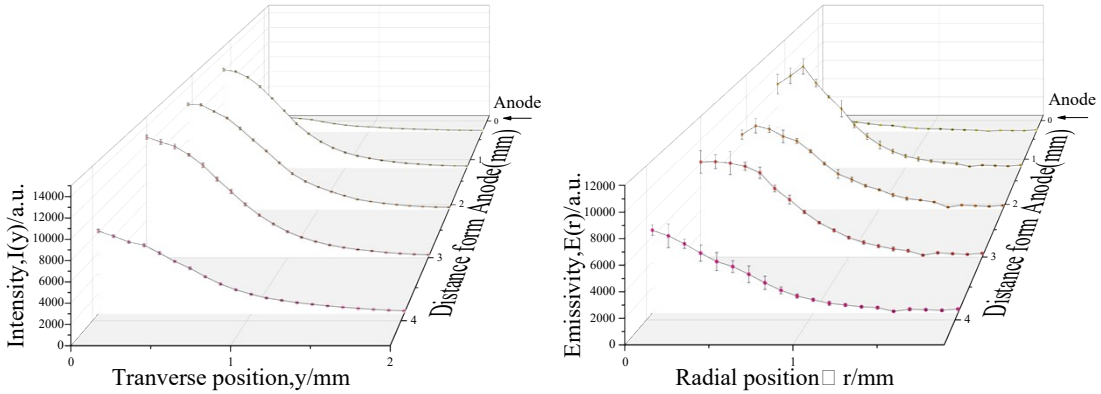
(a) (b)

Fig. 9 Concentrated element K before and after Abel inversion; (a) Single-sided lateral distribution of spectral intensity; (b) Radial distribution of emissivity after Abel inversion. Conditions: 0.5 mg per L K, supporting electrolyte: HNO_3, solution pH: 1.0, discharge current: 70 mA, and flow rate: 2.92 mL min^{-1}.



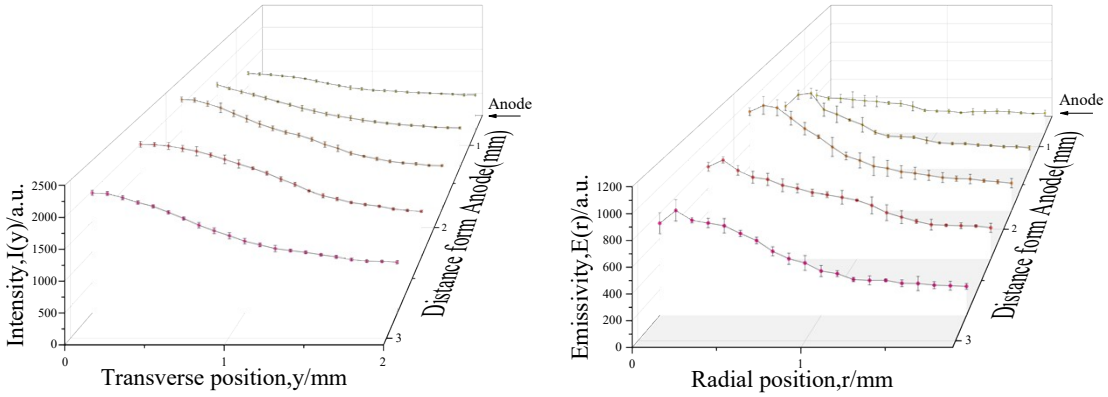
(a) (b)

Fig. 10 Semi-concentrated element Ag before and after Abel inversion; (a) Single-sided lateral distribution of spectral intensity; (b) Radial distribution of emissivity after Abel inversion. Conditions: 2 mg per L Ag, supporting electrolyte: HNO_3, solution pH: 1.0, discharge current: 70 mA, and flow rate: 2.92 mL min^{-1}.



(a) (b)

Fig. 11 Semi-diffuse element Cu before and after Abel inversion; (a) Single-sided lateral distribution of spectral intensity; (b) Radial distribution of emissivity after Abel inversion. Conditions: 2 mg per L Cu, supporting electrolyte: HNO_3, solution pH: 1.0, discharge current: 70 mA, and flow rate: 2.92 mL min^{-1}.



(a) (b)

Fig. 12 Diffuse element Cd before and after Abel inversion; (a) Single-sided lateral distribution of spectral intensity; (b) Radial distribution of emissivity after Abel inversion. Conditions: 2.5 mg per L Cd, supporting electrolyte: HNO_3, solution pH: 1.0, discharge current: 70 mA, and flow rate: 2.92 mL min^{-1}.

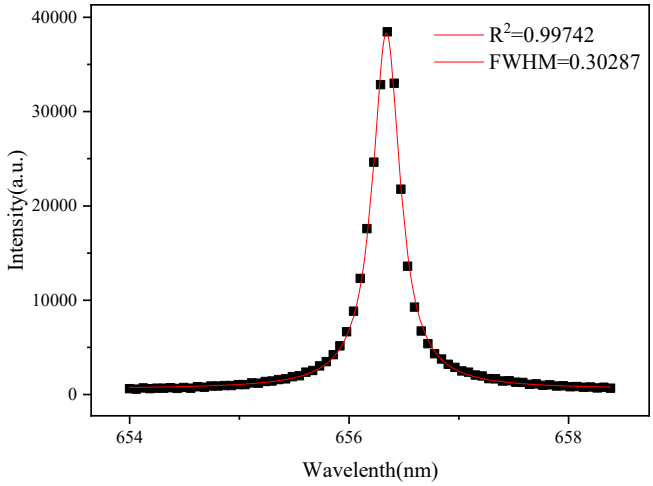


Fig. 13 The Lorentzian fitting of H_α (656.35 nm).

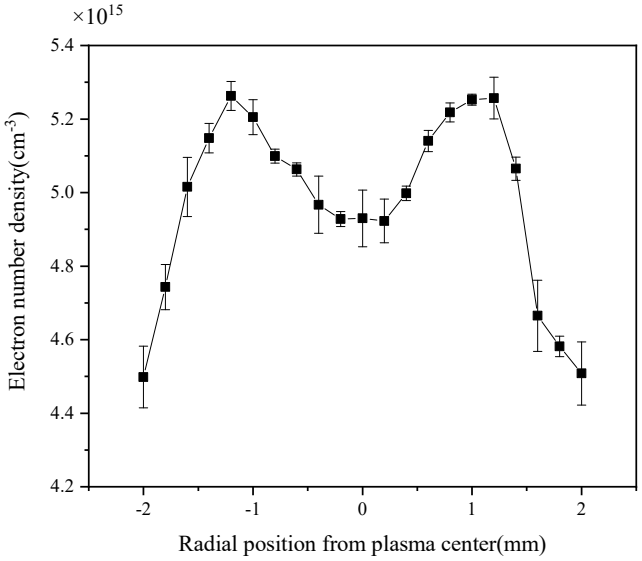


Fig. 14 Radial distribution of electron number density. Conditions: supporting electrolyte: HNO_3, solution pH: 1.0, discharge current: 70 mA, and flow rate: 2.92 mL min^{-1}.

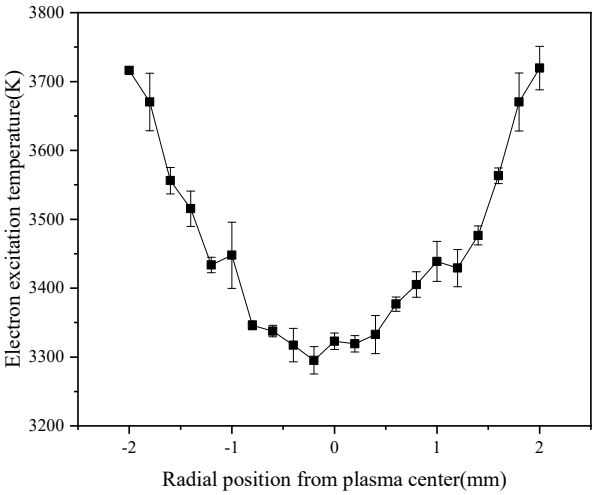


Fig. 15 Radial distribution of plasma electron excitation temperature. Conditions: supporting electrolyte: HNO_3, solution pH: 1.0, discharge current: 70 mA, and flow rate: 2.92 mL min^{-1}.

Table1:

Vertical profile maximum spectral intensity (I_{max}), maximum SBR (S/B_{max}), and minimum DLs (DLs_{min}) for various elements in SCGD, measured from the anode surface.

Element， Wavelength	Position of S/B_{max} (mm)	Position of I_{max} (mm)	Position of DLs_{min} (mm)
Concentrated			
K I,766.95nm	3.5	3.5	3.5
Rb I,780.16nm	3.7	3.7	3.6
In I,450.61nm	3.3	3.3	3.3
Semi-concentrated			
Ca I, 622.85nm	1.9	1.9	1.9
Ag I, 328.96nm	3.2	3.1	3.1
Semi-diffuse			
Cu I,327.31nm	1.4	1.5	1.5
Mn I,403.76nm	1.5	1.6	1.5
Diffuse			
Cd I, 228.78nm	1.8	1.9	1.8

Table2**:**

Spectroscopic parameters of the selected lines of H_α and H_β.

Element	Wavelength(nm)	Transition Probability (s^{-1})	Upper Level Energy(eV)	Lower Level Energy(eV)
H_α	656.6nm	5.38×10^7	12.08	10.19
H_β	486.1nm	1.71×10^7	12.74	10.19

Table3:

Comparison of DLs for elements.

Element	Wavelength (nm)	DLs (μg/L)		Improvement factor
		Transverse position y=0	Abel inversion maximum point position	
K	766.95	1.2	0.3	4.0
In	450.61	22.4	9.7	2.3
Rb	780.16	2.5	1.5	1.7
Ag	328.96	17.8	9.3	1.9
Ca	622.85	58.2	45.19	1.3
Cu	327.31	55.2	40.2	1.4
Mn	403.76	94.2	86.6	1.1
Cd	228.78	27.1	19.4	1.4