

Introduction

- Ammonia (NH₃) is a promising carbon-free fuel, yet constrained by slow chemical kinetics. Nanosecond pulsed plasma effectively enhances its reactivity, with the NH radical acting as a crucial intermediate bridging NH₃ decomposition and H₂ formation.
- Employ nanosecond-resolved NH-LIF in a DBD reactor to visualize the spatiotemporal evolution of NH radicals under varying discharge frequencies and N₂ dilution, providing direct experimental benchmarks for plasma-chemical modeling.
- Employ 0D solver ChemPlasKin to unmask the dominant reaction pathways and radical-interaction mechanisms during NH₃ decomposition.

Experimental Setup

Experimental setup & Spectra calibration

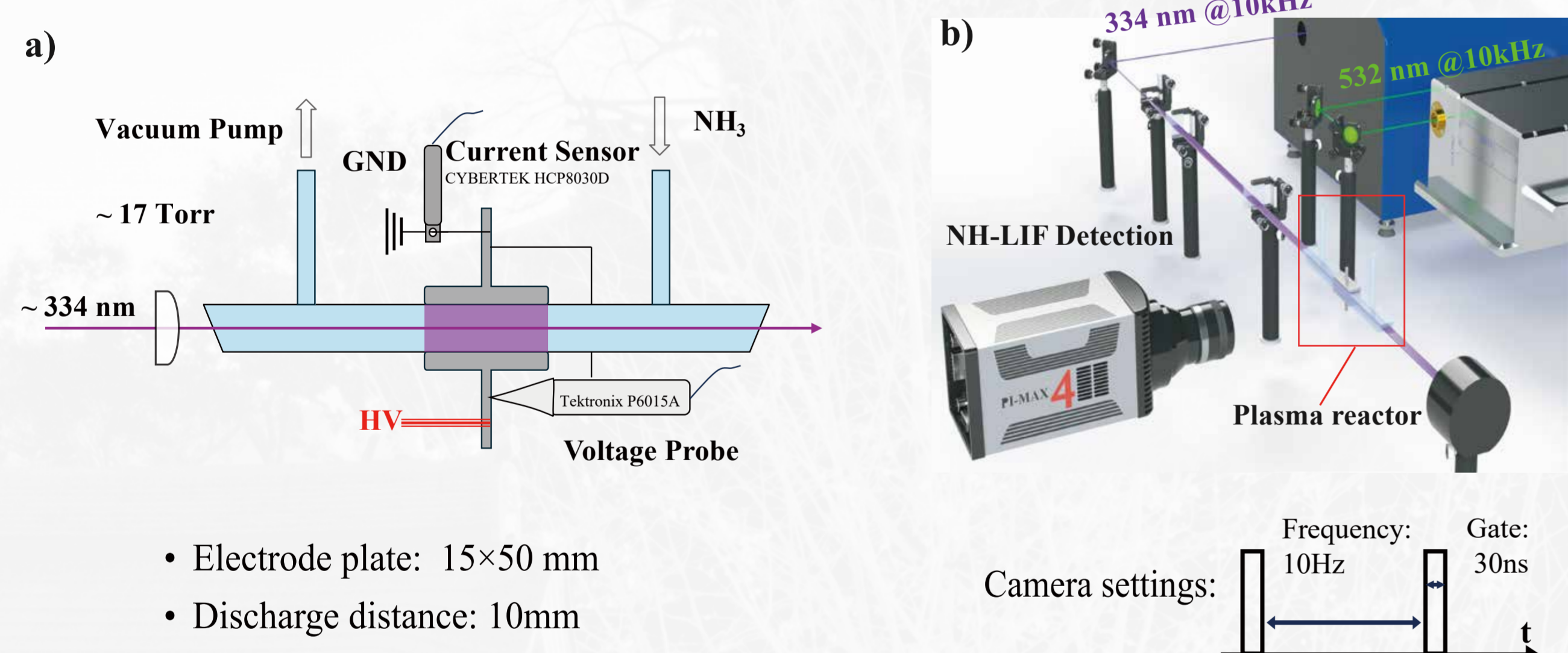


Fig. 1 (a) Diagram of DBD reactor. (b) Schematic of the optical diagnostic setup.

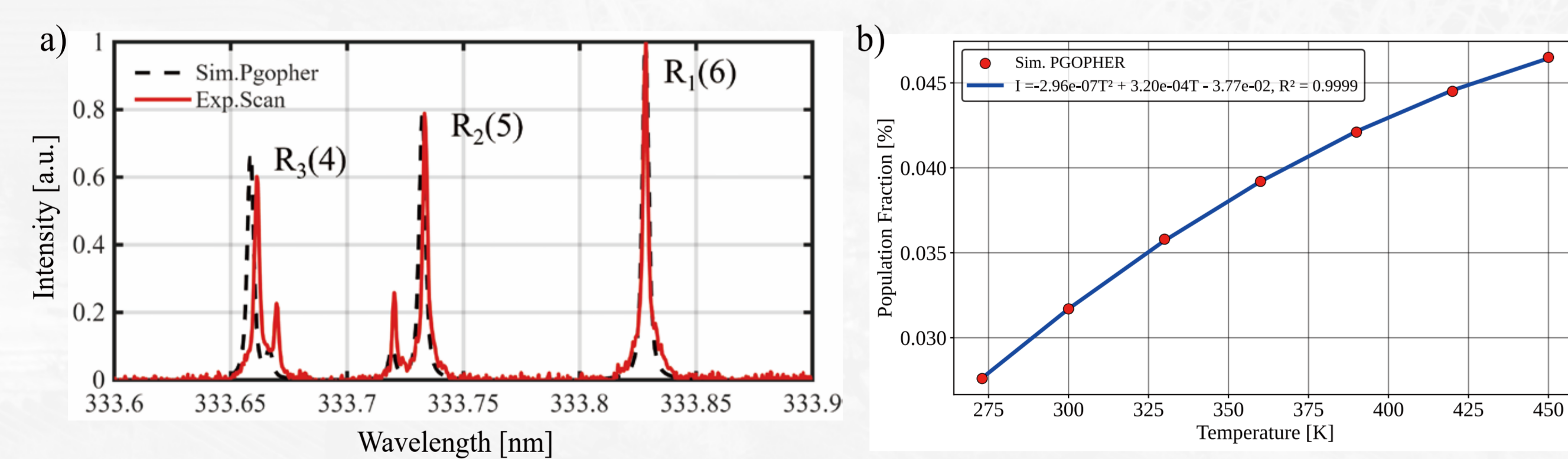


Fig. 2 (a) Comparison between simulated and experimentally measured NH excitation spectra (b) Simulated rotational temperature dependence of the NH-LIF signal intensity for the R₁(6) transition.

Results and Discussion

Spatiotemporal evolution of NH radicals

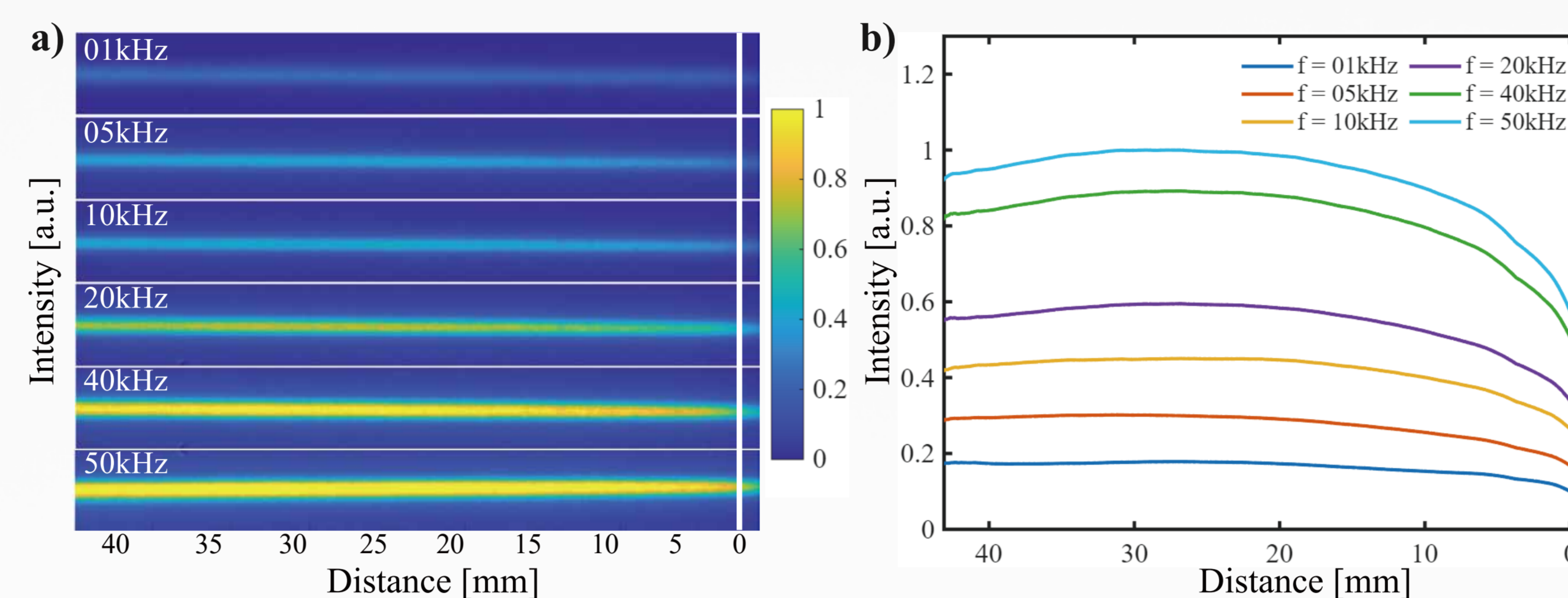
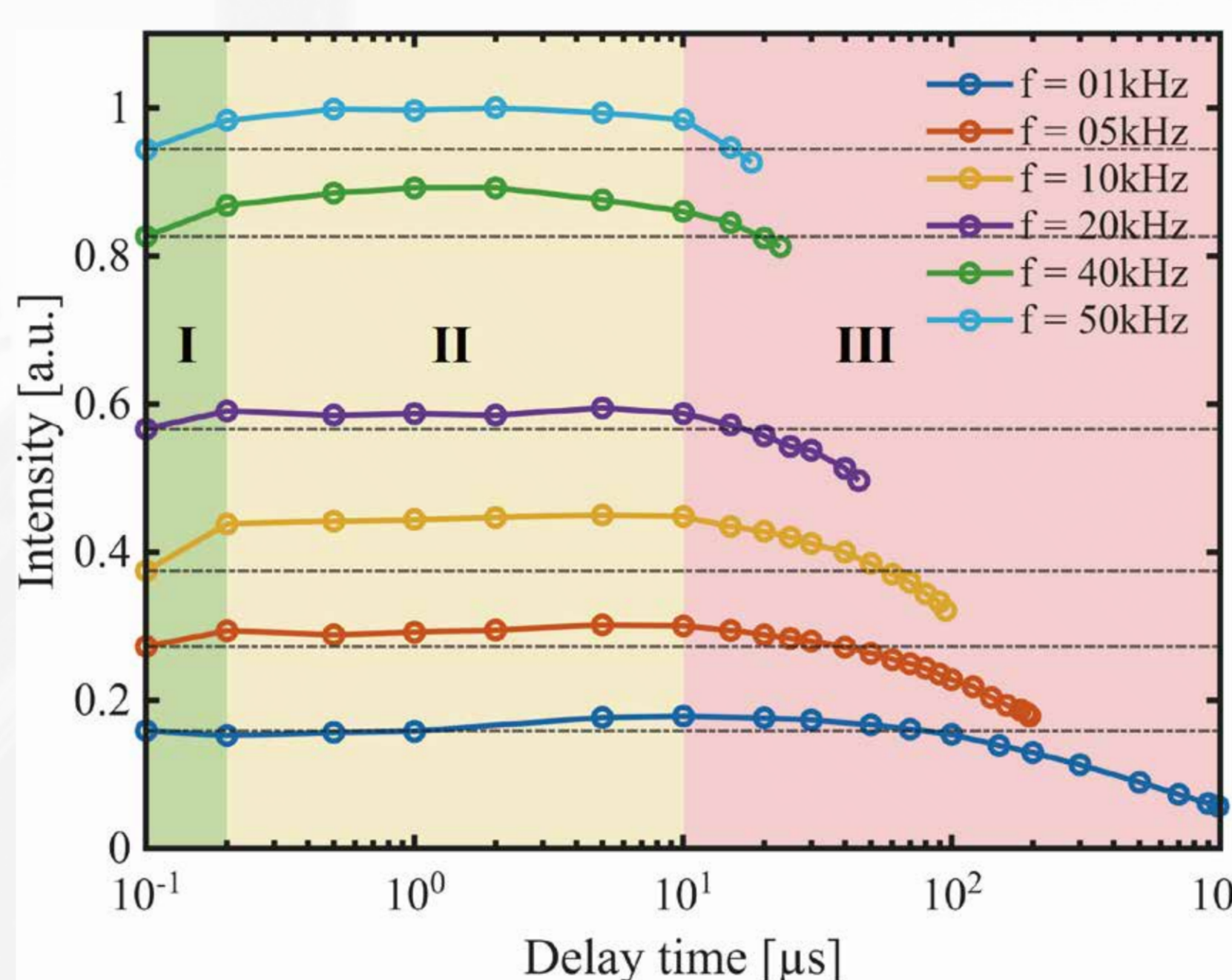


Fig. 3 Spatial distributions of NH-LIF signals in pure NH₃ at 1 μs after the discharge. (a) 800 phase-averaged NH-LIF images where the white solid line represents the edge of the electrode plate. (b) Streamwise profiles of NH-LIF along the flow direction (from right to left).



- I: Rapid Formation
- II: Quasi-Steady State
- III: Slowly Decay

Fig. 4 Time evolution of NH fluorescence in pure NH₃ at different discharge frequencies. The dotted lines indicate the NH-LIF intensity at 100 ns after the discharge.

Influence of N₂ dilution on NH generation

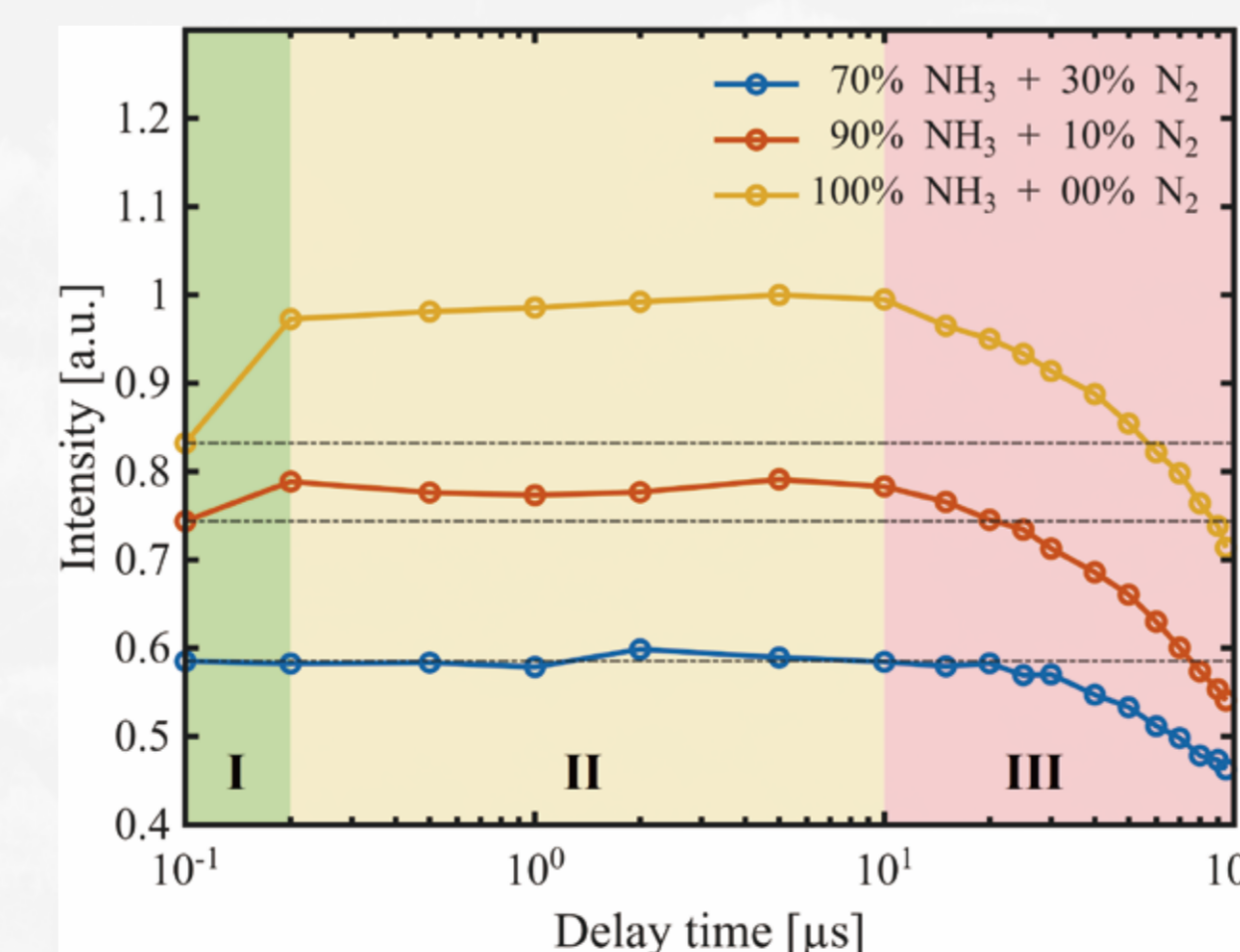


Fig. 5 Time evolution of NH fluorescence in NH₃ with different N₂ dilution ratios.

Condition	NH ₃ (%)	N ₂ (%)	Pressure (Torr)
1	100	0	
2	90	10	~17
3	70	30	

Table 1: Summary of flow conditions

- Consistent temporal trend.
- N₂ ↑ → n_e ↓ → NH ↓

Optical emission spectra of NH₃ plasma

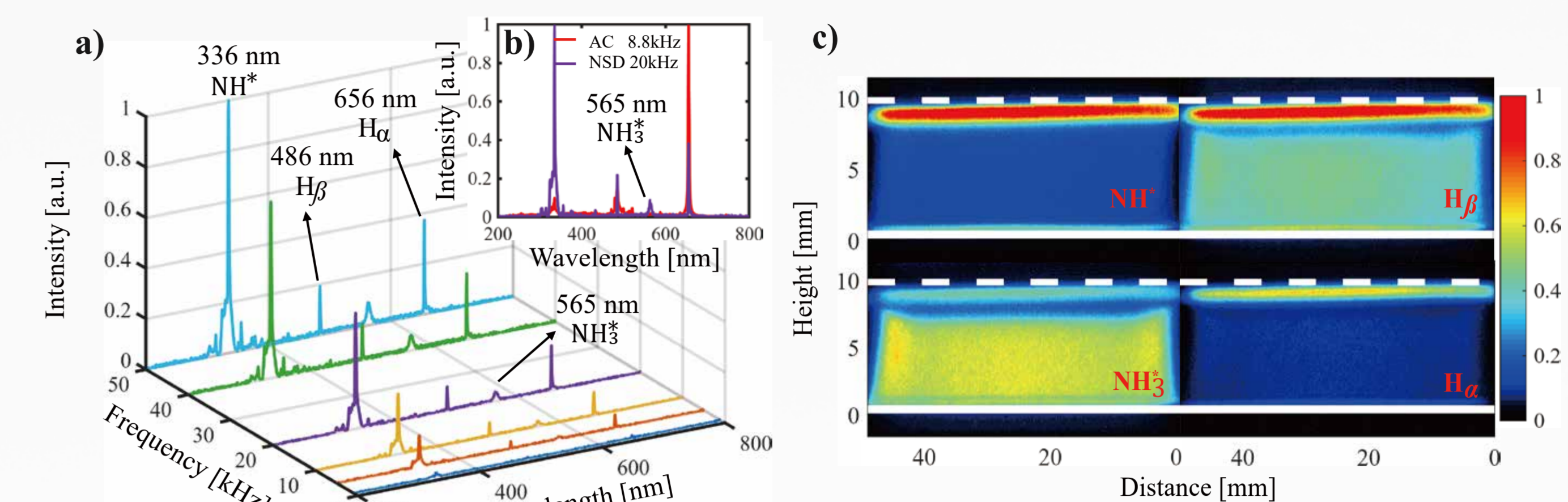


Fig. 6 (a) OES of pure NH₃ at different discharge frequencies. (b) OES of NH₃ under an AC gliding arc discharge [2] (c) 2D imaging of NH (⁴P₁-³P₂), H_β, NH₃^{*}, and H_α. The solid and dashed white lines indicate the anode and cathode plates, respectively.

Numerical Simulation

NH₃ conversion path analysis & Path flux of NH

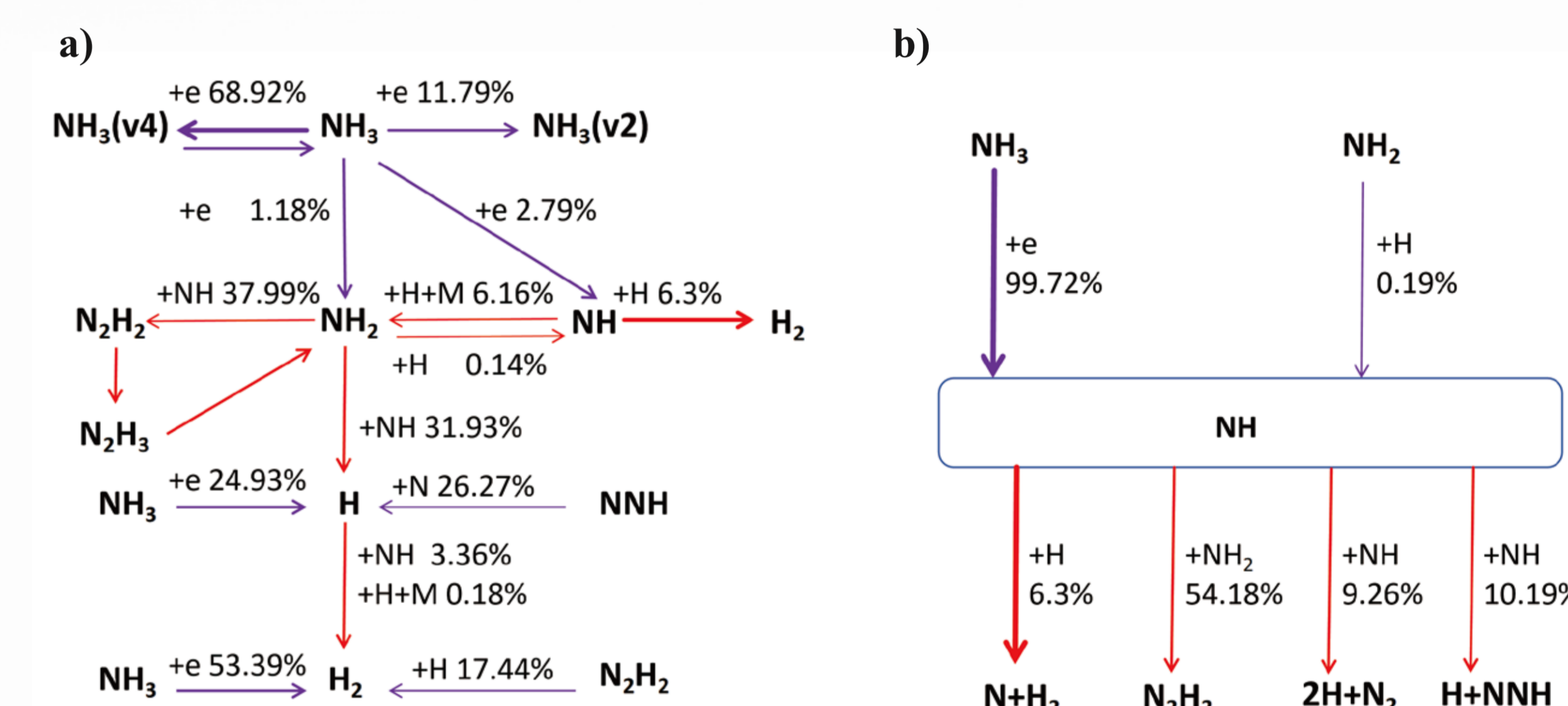


Fig. 7 (a) NH₃ conversion path analysis (b) Path flux analysis of NH in pure NH₃ under 10 kHz discharge.

- Condition: Pure NH₃ under 10 kHz.
- Simulator: 0D solver ChemPlasKin.
- Chemical kinetic mechanism: Refer to reference [3].

Conclusions

- This work characterizes the spatiotemporal evolution of transient NH radicals during plasma-assisted NH₃ decomposition using NH-LIF diagnostics and 0D kinetic simulations.
- The systematic investigation reveals a distinct **three-stage temporal evolution** with a lifetime exceeding 1 ms, and demonstrates that while higher discharge frequencies significantly promote NH production, N₂ dilution strongly suppresses it.
- These findings provide a vital experimental benchmark for **validating plasma-chemical kinetic models**.

[1] Z. Wang, W. Gu, C. Dong, Y. Liu, X. Liu, B. Zhou, High speed imaging of NH radicals in NH₃/H₂ turbulent flames, Fuel 427 (2027) 139856.

[2] T. Yu, H. Zhang, Z. Zhao, C. Kong, R. Zhang, J. Zhu, B. Zhou, Characteristics of an AC rotating gliding arc discharge in NH₃ and air atmospheres, Phys. Plasmas 31 (2) (2024) 023501.

[3] N. Liu, B. Mei, X. Mao, Z. Wang, Z. Sun, Y. Xu, Z. Shi, Y. Ju, Kinetics of low temperature plasma assisted NH₃/H₂ oxidation in a nanosecond-pulsed discharge, Proc. Combust. Inst. 40 (1-4) (2024) 105353.