Towards lower energy cost of NO production in atmospheric air discharges

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Ecologically optimized production of N- containing compounds at the atmospheric conditions is of a great importance. This is dictated by the abundance of (hard to dissociate) molecular nitrogen in the Earth atmosphere and by the necessity to replace the existing Haber-Bosch process, which is used for N- containing compound production since the beginning of XX-th century featuring high energy consumption and high CO_2 emission, [1,2] the issues which still should be overcome.

The ways for energy cost reduction during the NO radical formation in atmospheric air discharges are analyzed in this work. For this purpose, a non-equilibrium discharge working in corona, spark and glow regimes are studied by laser spectroscopy showing the optimum performance in the vicinity of spark-to-glow transition. The minimum energy cost for NO production of about 80 eV/molecule (based on the *total direct current power* applied to the discharge) is found in the spark regime before the transition, whereas the maximum NO yield (of about 10^4 ppm) corresponds to the glow discharge regime. Based on the *power absorbed in plasma* the energy cost of only about 4 eV/molecule is achievable in the spark regime, which is close to the Zeldovich reaction enthalpy of NO formation (~ 3 eV/molecule). The result implies that the energetic efficiency of a single spark likely exceeds that of the modern Haber-Bosch cycle (currently reported value is about 5 eV/molecule in the case of ammonia, according to Patil et al. [1] The found low energy cost is associated with the discharge non-equilibrium caused by short (ns) spark duration.

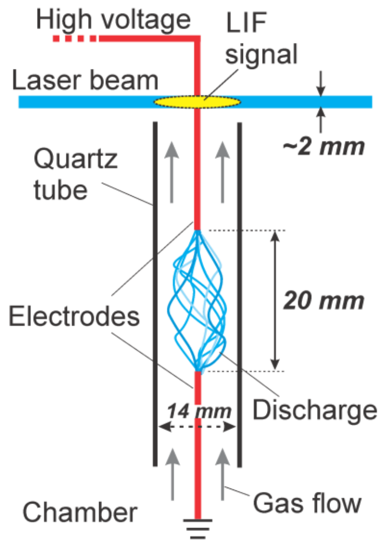

Figure 1. The schematics of the discharge. The system was operated in a chamber at about 0.98 atm.

References
[1] B. Patil, Q. Wang, V. Hessel, and J. Lang, Catalysis Today **256**, 49 (2015).
[2] N. Cherkasov, A. Ibhadon, and P. Fitzpatrick, Chem. Eng. Proc.: Process Intensification **90**, 24 (2015).

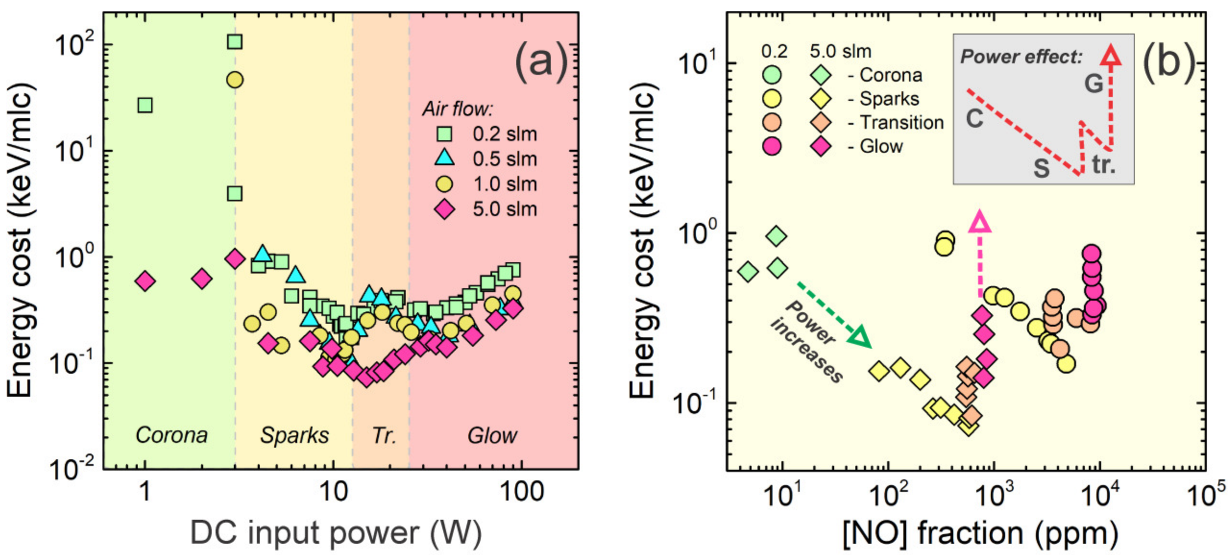

Figure 2. The corona-spark-glow discharge performance in the coordinates energy cost – input power (a) and energy cost – NO fraction produced (b). The energy cost – NO production pathways are sketched in the inset of (b) panel. (C – corona; S – sparks; tr. – transition; G – glow.)