Finite Element Method Plasma Simulation of Nitrogen Contaminated Ceramic Metal Halide Lamps

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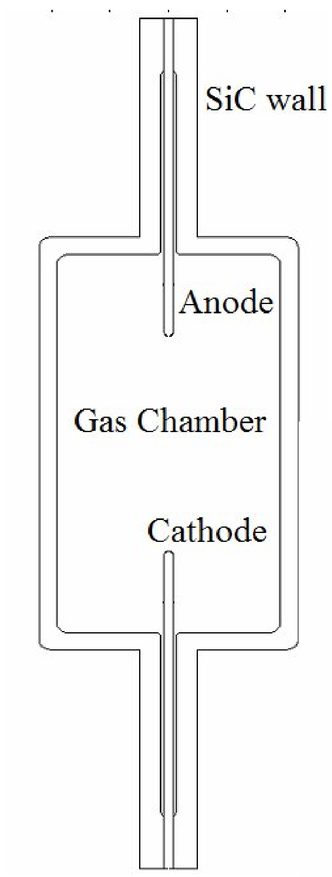
Introduction

The ceramic metal halide lamps belong to the most efficient high intensity light sources of these days. If some nitrogen gas gets into the lamp's interior, the lamp becomes unable to ignite.

Amongst others, the chemical reactions were one of the key features that were investigated to identify the critical nitrogen concentration that changes the plasma physical processes and the operation of the lamp significantly.

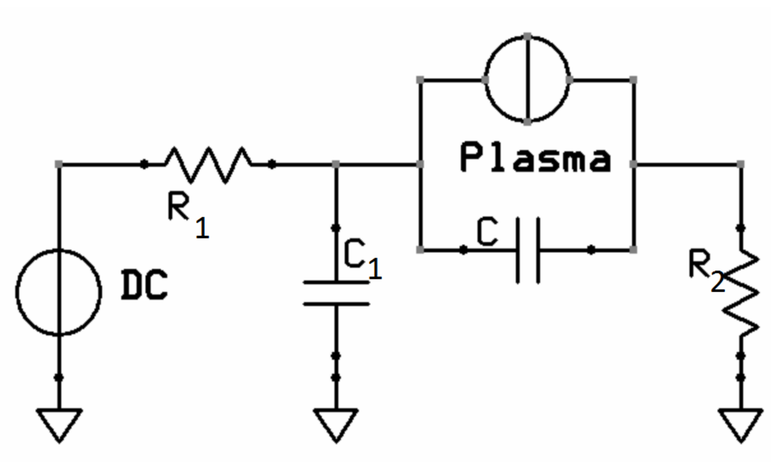


Structure of the lamp's gas chamber

Experimental Setup

The investigated lamp is a 70W CMH lamp produced by General Electric Lighting. As the lamp is axisymmetric, a two-dimensional axisymmetric model was used.

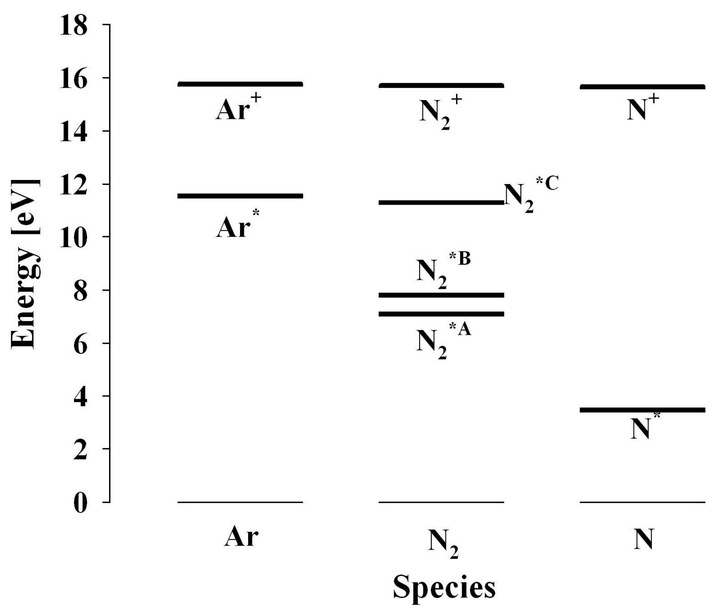
The model of the electrical circuit consists an ideal voltage source and an electric ballast.



Circuit diagram of the lamp

Particles

Only the main energy levels were included.
The star denotes the excited states, the + sign indicates ionized states.



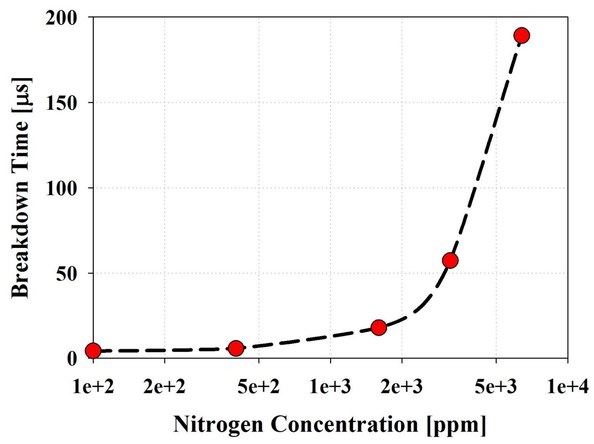
Reactions

There were numerous electron impact and heavy particle reactions included that were set.
The excited or ionized particles get into ground state while interacting with the surfaces.

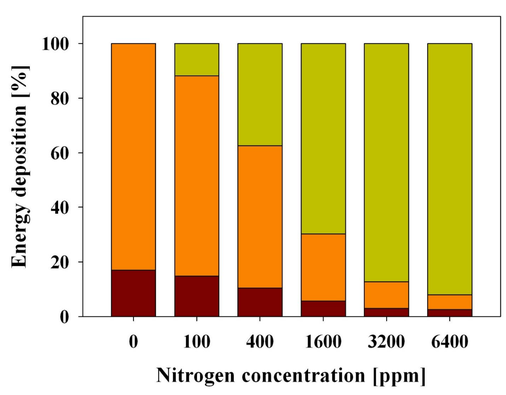
Results

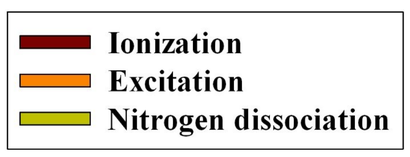
The breakdown process was examined with different nitrogen concentrations.

As the nitrogen concentration becomes more significant, the ignition time increases, and the ratio of energy expended on the ionization gets lower. At the same time the effects of nitrogen dissociation determinative. The reason for this is the reactions' forward rate constants.

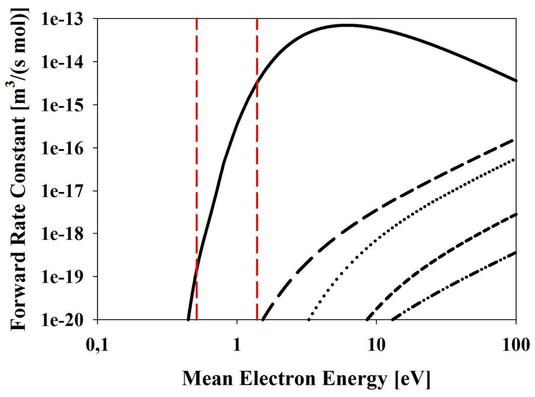


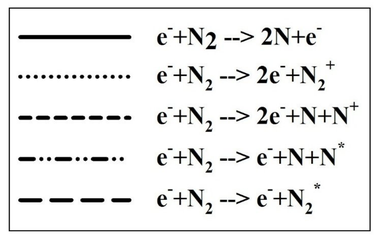
Time needed for the breakdown





Energy consumed by the different reaction types





Forward rate constants of the included electron--nitrogen reactions

Conclusion

Nitrogen contamination hinders the emergence of breakdown, because of the high cross section of $e^- + N_2 + 9.8407eV \rightarrow e^- + 2N$ nitrogen dissociation reaction. Above a nitrogen concentration of 500 ppm, more than half of the electrons' energy is lost because of the nitrogen dissociation reaction.

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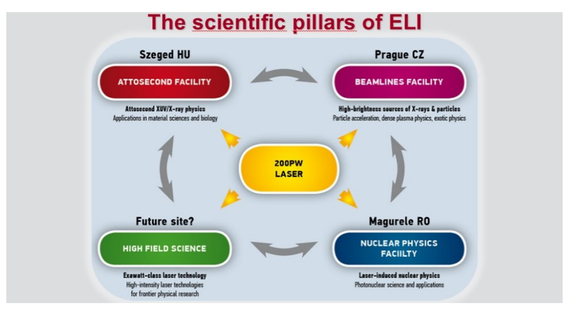
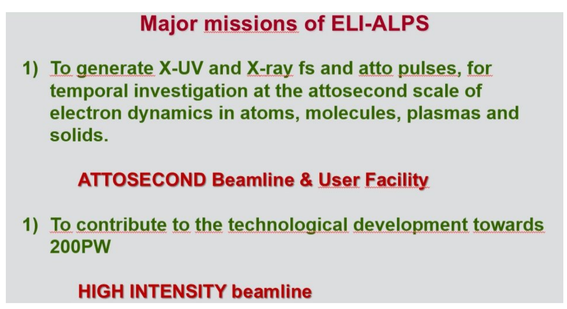
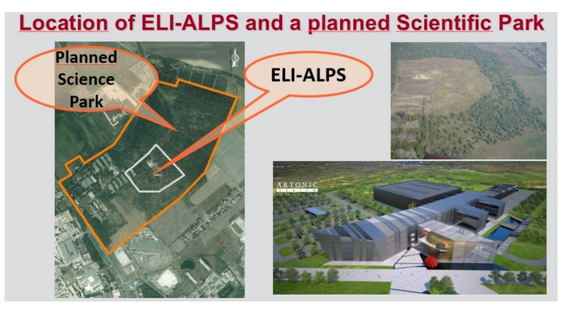
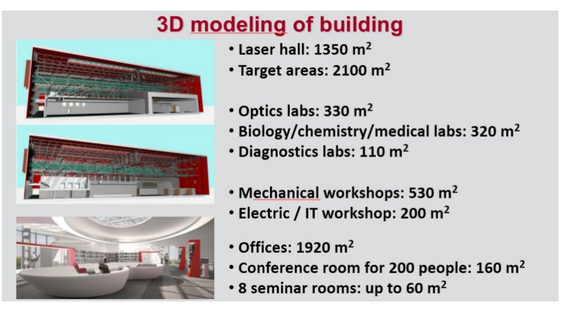
NEW SZÉCHENYI PLAN









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