RADIATION-INDUCED DESORPTION OF EXCITED ATOMS FROM SOLID NITROGEN

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Motivation

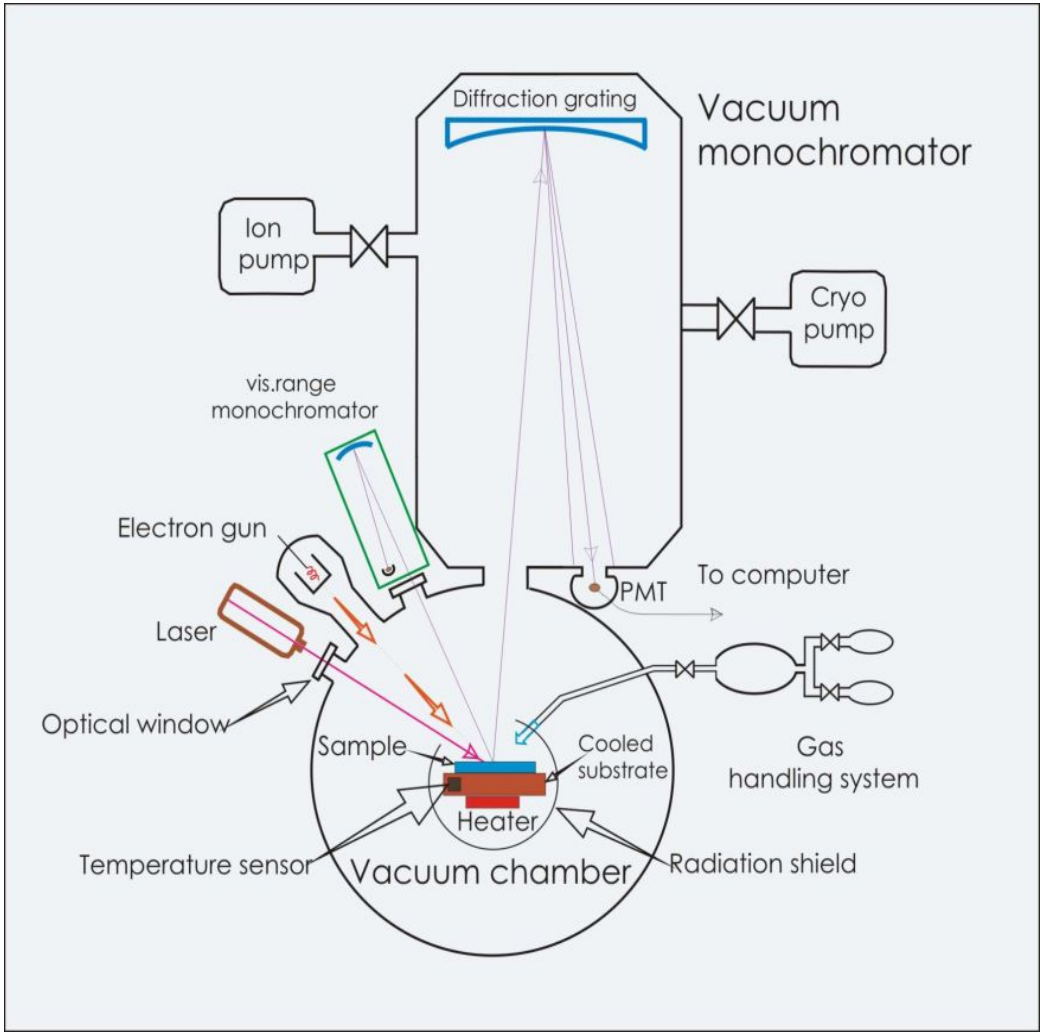
- Radiation effects in solid N_2 are very important in research of material and surface sciences, physics and chemistry of interstellar space and solar system and also particle physics

- Electronically induced desorption and luminescence are effective tools for the study of electron-stimulated processes in solids

- Despite extensive studies the contribution of excited atoms into the desorption is still not well understood.

- In the present paper radiation processes in the solid nitrogen irradiated with an electron beam were studied with special attention to the desorption of the excited atoms and its contribution to the electron-stimulated phenomena in general.

Experimental setup



Base pressure - **10^{-8} mbar**

Liquid Helium cryostat T is controlled with a **Si diod**

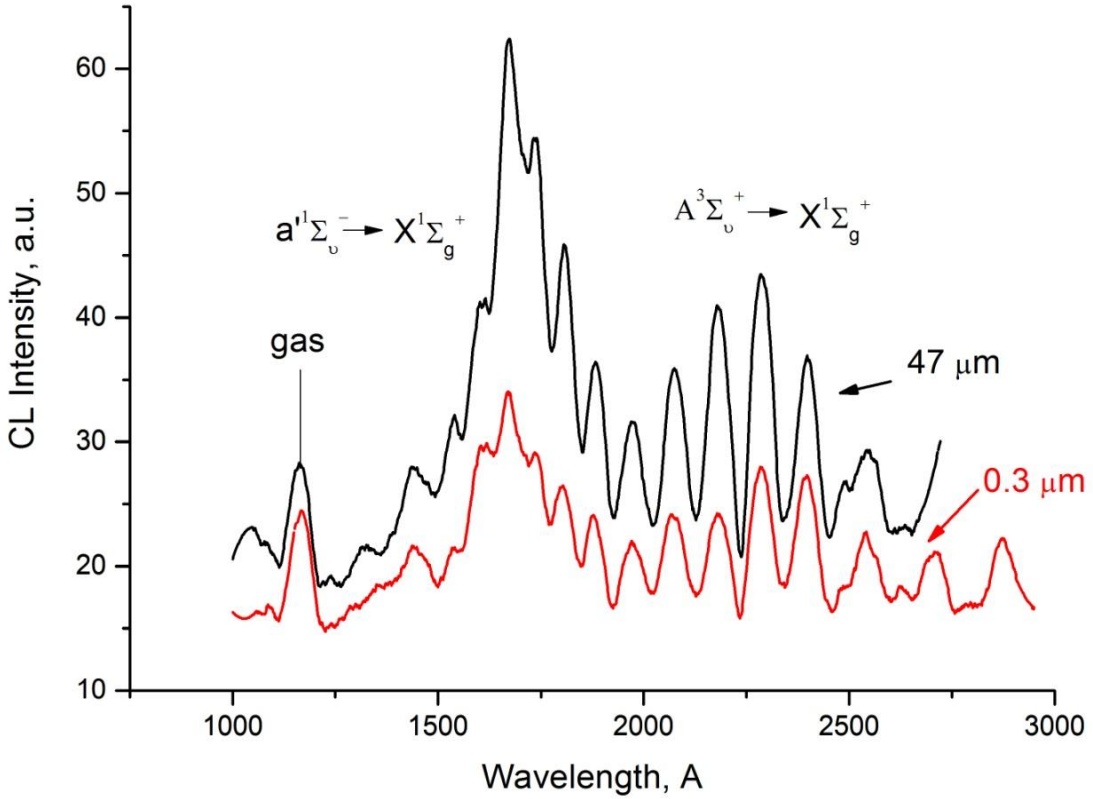
Sample deposition from the gas phase:
Variable thickness **100 – 10000 nm**
Variable film structure
Open sample surface

Luminescence is recorded **simultaneously in VUV and visible range**

Can be measured not only total yield of TSL, but also **spectrally resolved TSL yields in VUV and visible ranges**

Optical and current **relaxation emission** e.g. TSL, OSL and TSEE, OSEE as well as pressure in the chamber **are detected simultaneously**

Spectroscopic observation of excited atoms desorption

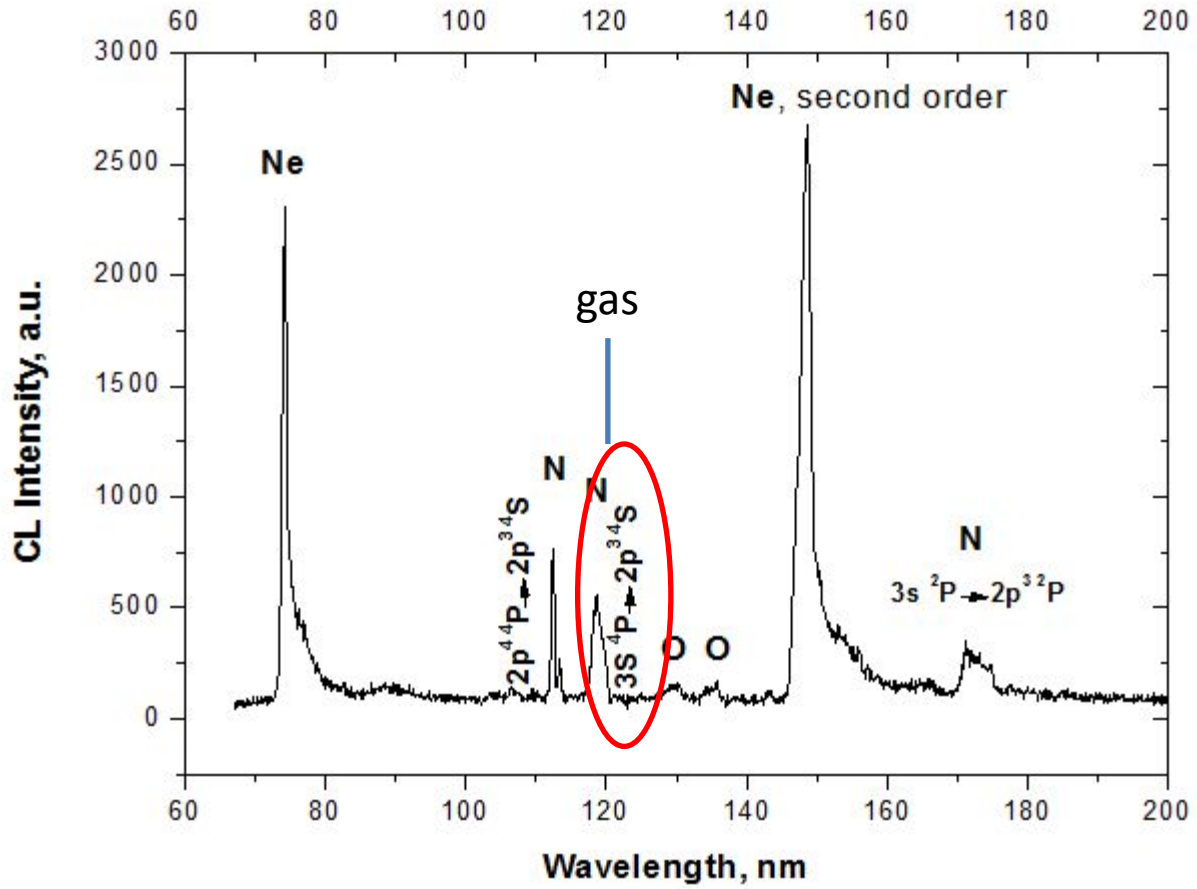


Atomic emissions increased with respect to the bulk molecular emissions in thin films

Atomic emissions peaks coincide with the spectrum of the gas phase.

These 2 facts are the evidence of excited N_2 atoms desorption

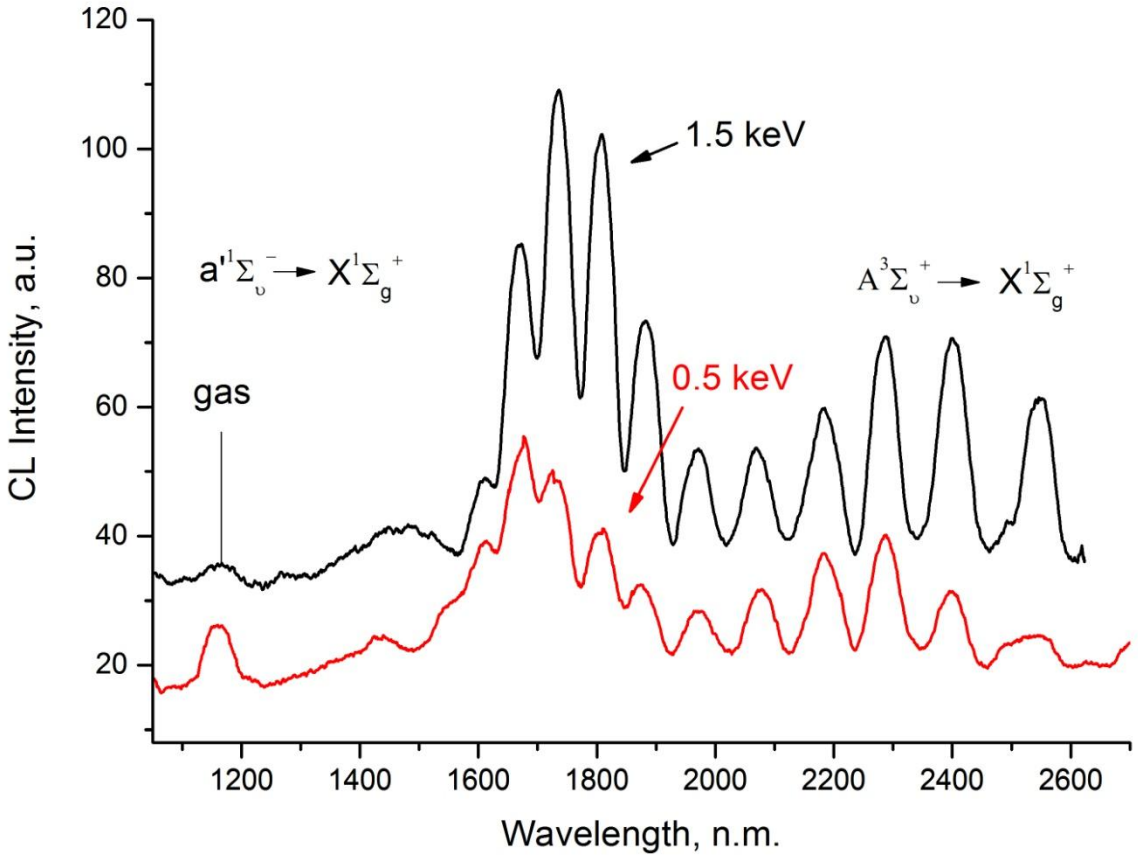
VUV emission of nitrogen atoms in Ne matrix



Matrix shift of N atomic transitions in neon matrix

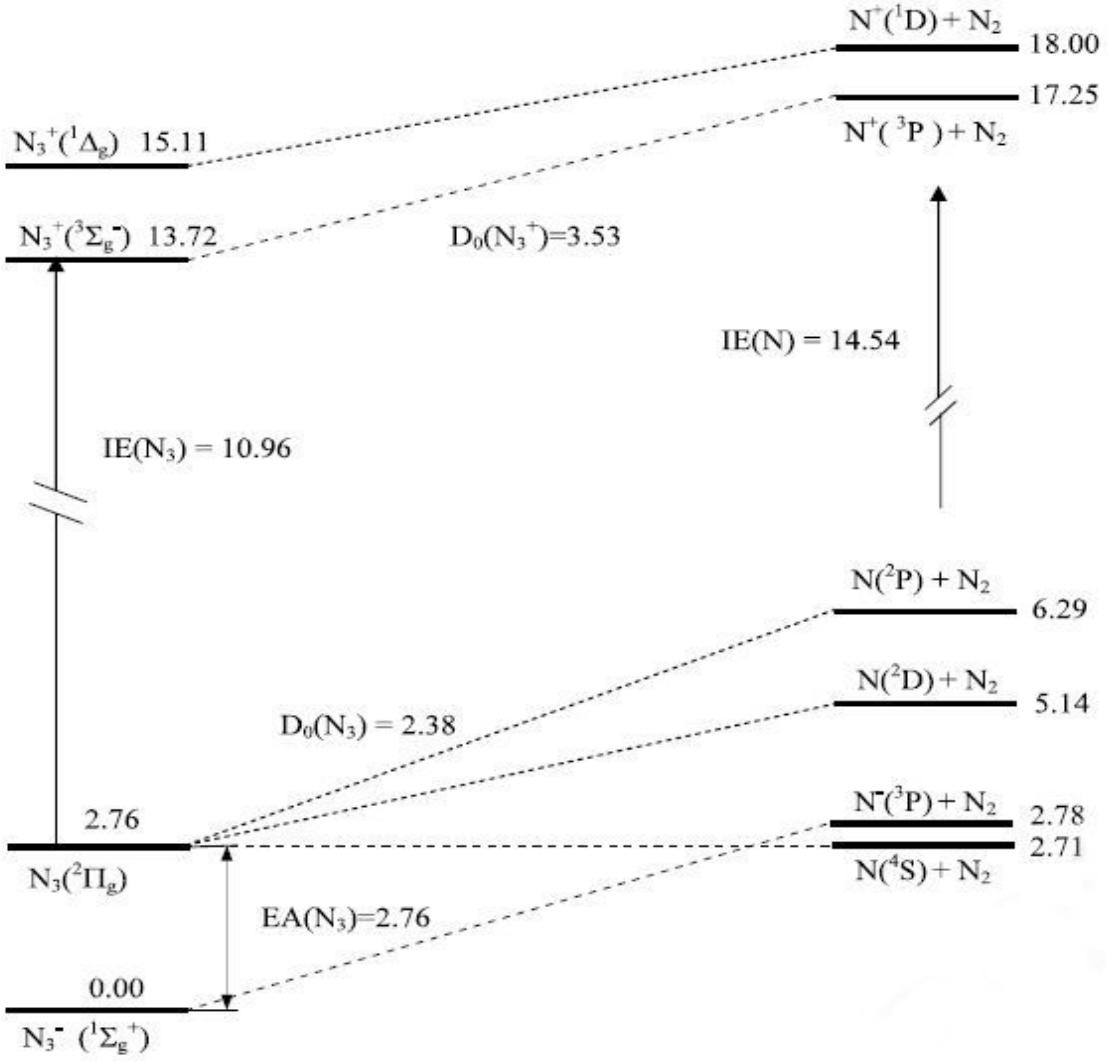
$\Delta E = E_m - E_g = 0.04$ eV

Sample probing by depth



Atomic emissions increased under irradiation by slower electrons which have less penetration depth.

Scheme of relative energies of the trinitrogen system



From M.T. Nguyen, Coord. Chem. Rev. **244** (2003) 93

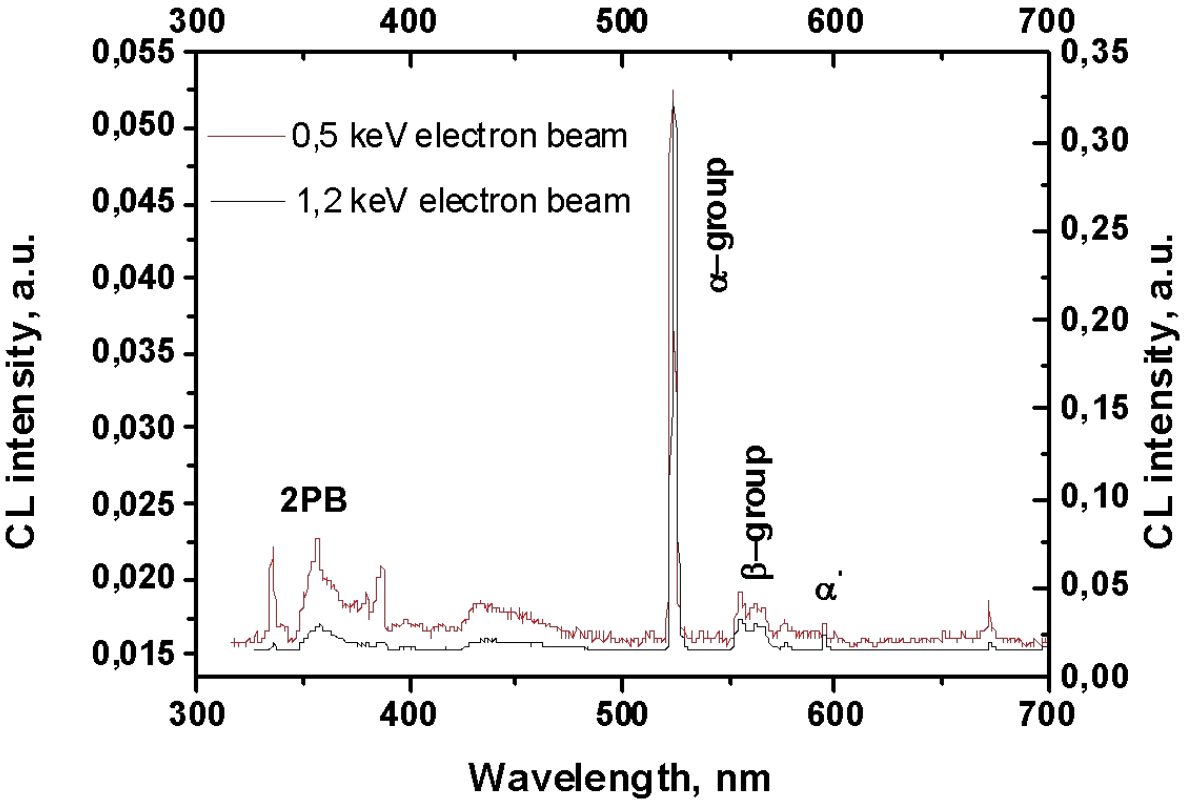
In the dissociative recombination of N_3^+ two-body and three-body channels are exothermic

$$N_3^+ + e^- \begin{cases} N_2 + N + 10.5\ eV \\ N + N + N + 0.7\ eV \end{cases}$$

A strong propensity to dissociate via the N_2 + N channel has been observed for the azide radical cation N_3^+ in the gas phase.

V. Zhaunerchyk et al., J. Chem. Phys. 127 (2007) 014305.

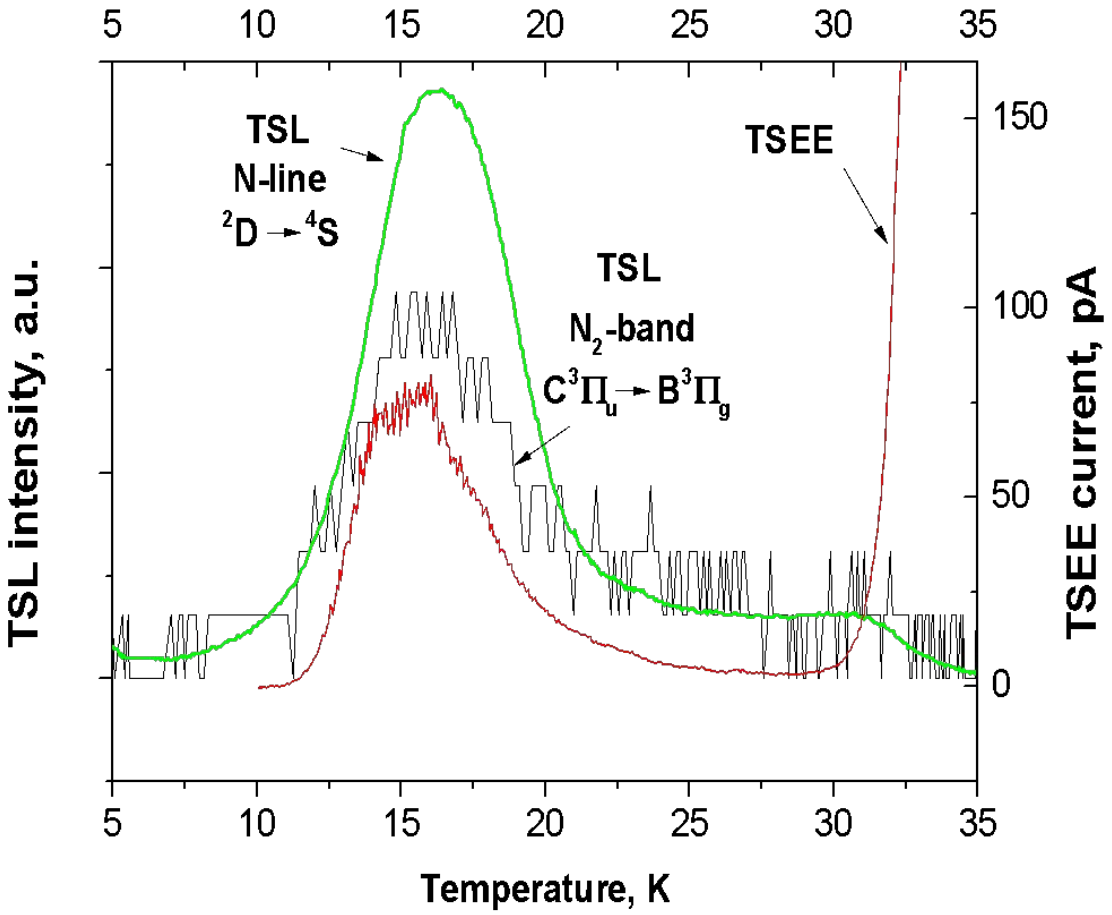
Desorption of excited N_2 molecules: sample probing by depth



Luminescence spectra of solid N_2 excited with 0.5 keV and 1.2 keV electron beam

Second positive system intensity increases when the penetration depth of electrons is decreased.

Activation spectroscopy of pre-irradiated Nitrogen



$$N_3^+ + e^- \rightarrow N_2 + N + h\nu_a$$

Neutralization reaction provides the source of energy for the desorption

Summary

- ✔ The study of spectra evolution under irradiation provided information on defect production and accumulation, molecule fragmentation and particle desorption

- ✔ Analysis of cathodoluminescence CL spectra of solid N_2 and N_2 isolated in Ne matrix and study of the thin films together with probing the samples by depth helped us to reveal the contribution of excited atoms into the desorption.

- ✔ The dissociative recombination of N_3^+ with electron is suggested to be a key process underlying the desorption of electronically excited atoms.

$$N_3^+ + e^- \rightarrow N_2 + N^* + h\nu_a$$