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# Optical spectroscopy and current detection during warm-up and destruction of impurity-helium condensates

It is well known that deposition of rare gases (RG) passed through electrical discharge area onto a cold (~ 4 K) surface, or irradiation of cryofilms by energetic particles (electrons, protons, or photons with energies of 20 eV – 4 MeV) can cause formation and stabilization of neutral radicals and ions. Recent experiments have revealed ion currents accompanied by luminescence during destruction of nitrogen-helium condensates prepared by condensation of nitrogen-helium gas mixtures (after passing through a radio frequency RF discharge zone) into superfluid helium (HeII) bulk [1].

**Key words:** condensate, spectroscopy, cryocondensates surface.

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**Оптическая спектроскопия и определение тока во время прогрева и разрушения примесь-гелиевых конденсатов**

Хорошо известно, что осаждение благородных газов (Rg), прошедших через электрическую разрядную область на холодную (~ 4 К) поверхность, или облучение криопленок энергоемкими частицами (электроны, протоны, или фотонов, с энергией 20 эВ - 4 МэВ), может привести к формированию и стабилизации нейтральных радикалов и ионов. Недавние эксперименты показали, ионные токи, сопровождающиеся люминесценции в процессе распада азотно-гелиевых конденсатов, полученных конденсацией газовых смесей азот-гелий (после прохождения через зону радиочастотного ВЧ разряда) в сверхтекучий гелий (HeII) [1].

**Ключевые слова:** конденсат, спектроскопия, криоконденсат, поверхность.

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**Оптикалық спектроскопия және қоспа-гелийлі конденсаттардың қыздырылуы және бұзылуы кезіндегі токты анықтау**

Электрлік разрядталған аумақтан суық (~ 4 К) бетке өткен асыл газдарды (Rg) тұндыру немесе криоқабықшаларды энергия сыйымдылықты бөлшектермен (электрондар, протондар немесе фотондар, 20 эВ – 4 МэВ энергиямен) сәулелендіру бейтарап радикалдардың және иондардың қалыптасуына және тұрақтандырылуына алып келуі мүмкін екені жақсы белгілі.

**Түйін сөздер:** конденсат, спектроскопия, криоконденсат, бет.

## Introduction

It is well known that deposition of rare gases (RG) passed through electrical discharge area onto a cold (~ 4 K) surface, or irradiation of cryofilms by energetic particles (electrons, protons, or photons with energies of 20 eV – 4 MeV) can cause formation and stabilization of neutral radicals and ions. Recent experiments have revealed ion currents accompanied by luminescence during destruction of nitrogen-helium condensates prepared by condensation of nitrogen-helium gas mixtures (after passing through a radio frequency RF discharge zone) into superfluid helium (HeII) bulk [1]. We present new experimental results on detection of optical spectra and ion currents during thermostimulated destruction of impurity-helium condensates (IHCs) prepared from nitrogen-argon-helium and nitrogen-xenon-helium gas mixtures.

**Experimental Method and Results**

The experimental technique of IHC sample preparation was first developed in 1974 [2]. It is based on the injection of a helium gas jet containing impurity particles (Im = N, $N_2$, H, $H_2$, Ne, Ar, etc.) into bulk HeII. A gas mixture enters a helium bath region from a quartz capillary cooled with liquid nitrogen inside an atom source. The lower portion of the capillary is surrounded by electrodes to produce an RF discharge (f = 40 MHz, P = 40-90 W). The typical conditions during sample preparation were as follows: the impurity admixture, [Im]/[He] ~ 0.5-1 %, the gas jet flux

(4.5-6)·1019 s-1, the HeII temperature 1.5 K, and the duration of the sample condensation 600-5000 s. The oxygen content in the gas mixtures is mainly a result of contamination of the helium gas. We employ helium gas with an oxygen content of ~ 10 ppm. A gas jet consisting of a mixture of helium and impurity gases was directed onto the surface of HeII contained in a glass beaker placed below the source at a distance of 20-35 mm. Calibrated Lake Shore thermometers were used for the temperature measurements. The sample emission was directly collected by an optical fiber fixed above an IHC sample in the beaker. The spectrometer AvaSpec-ULS2048XL-USB2 allowed us to detect luminescence within the spectral range from 200 to 1100 nm with resolution ~ 2.5 nm.

The spectra observed during destruction of impurity-helium condensates containing stabilized radicals reveal that all of the emitting particles are localized within solid matrices. The spectra of luminescence detected during the destruction of the second sample prepared from a gas mixture [$N_2$]/[Ar]/[He] = 1/10/1000 were changing on time. The dominance of emission due to species containing oxygen was explained by a multishell structure of impurity clusters: heavier particles (in this case O atoms) are involved in the reactions and the luminescence at the final stage of sample destruction when impurity clusters fuse together.

The luminescence spectra detected during destruction of the sample prepared from a gas mixture [Xe]/[$N_2$]/[He] = 1/10/2000 has revealed, for the first time, the spectra from molecules XeO*captured in N2 films surrounding the xenon cores of impurity nanoclusters.

The destruction of impurity-helium condensates containing stabilized radicals is accompanied with pressure and luminescence peaks, and current pulses (~ nA).

**References**

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