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Light emission of plasmons during ion bombardment of silver surfaces

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Photon emission during silver surface bombardment by H^+, H_2^+, H_3^+, He^+, Ne^+ and Ar^+ ions with energies from 7 to 21 keV was investigated. A continuum radiation was found in the spectral region from 200 to 630 nm with the energetic position of the maximum close to the plasmon energy of silver. The influence of the ion mass, energy and observation angle of radiation upon properties of this continuum radiation has been studied. The observed continuum radiation is linearly polarized. It is supposed that the observed continuum radiation is a result of radiative relaxation of silver plasmons.

1. Introduction

The bombardment of metal surfaces by ions with keV energies is accompanied by both emission of particles (electrons, ions, atoms, molecules) and photon emission. The spectrum of photon radiation in most cases consists of spectral lines emitted by sputtered and scattered particles. For some metals both molecular bands and continuum radiation (CR) have been observed [1]. In some experiments (see, e.g., ref. [2]), the nature of such molecular band emitters has been clarified. As a rule, these bands are due to the excited molecules of M_nA_m-type (where M and A are atoms of target and adsorbed gas, respectively, and n and m are numbers of atoms in corresponding molecules). The nature of CR emitters has so far not been established.

The subject of our report is the observation of continuum radiation of silver surfaces bombarded by positive gas ions. The spectrum of this radiation has a maximum in the ultraviolet region. The observed radiation was interpreted as radiative relaxation of collective excitations of a target electronic subsystem.

There are some reports [3–5] about the observation of CR which was supposed to be connected with one particle or collective excitations in metals. Zivitz and Thomas [3] considered that CR during Al bombardment by H^+ ions was due to electron–hole recombinations. Kobsev et al. [4] and Goldsmith and Jelley [5] observed the continuum radiation of silver surfaces during H^+ bombardment with energies from 1 to 5 MeV. They established it to be a transition radiation. On the contrary, Chaudri et al. [6] found out that the position of the maximum in CR spectra of silver surfaces was very close to the energy of plasma oscillations of electrons in silver. However, so far there were no experimental data (in the literature) about the observation of CR in ion-photon spectra which could be explained by the radiative relaxation of plasmons.

2. Experiment

In our experiments we used H^+, H_2^+, H_3^+, He^+, Ne^+ and Ar^+ ion beams with energies from 7 to 21 keV. The magnetic mass-analyzer with high resolution (dispersion 5 mm for 1% change of mass) and effective stabilization of ion beam parameters gave us the opportunity to obtain the ion flux with high intensity and homogeneity on masses and energies. The ions current density j varied from a minimal value $j = 1$ A/m^2 for 7 keV protons to a maximal value $j = 20$ A/m^2 for 21 keV helium ions. During bombardment by H_2^+ and H_3^+ ions with energies of 14–21 keV the values j were ~ 10 A/m^2.

Fig. 1 shows the geometry of the experiments. The ion bombardment of the target was carried out at the angles $\alpha = 10° - 80°$ from the surface normal. The directions of the primary ion beam and collection of radiation were arranged on one plane with the surface normal. The glow which was produced by ion bombardment of the surface was focused on the entrance slit of a grating monochromator and detected by a photomultiplier tube in the spectral region from 200 to 630 nm.

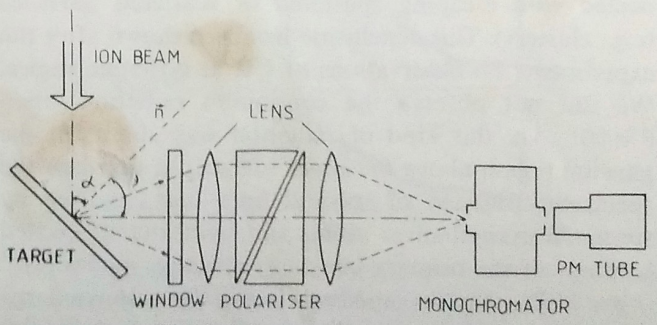

Fig. 1. Scheme of the experiment.