Spatial Distribution of Potassium Atoms Scattered from the (001) Surfaces of Lithium Fluoride

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Investigation of gas-solid interactions by means of molecular beams has recently attracted a great deal of attention.[1] The object of the study is to make clear the gas-surface interaction from the scattering of rare gases or hydrogen from clean surfaces of metals.[2] On the scattering of metal atoms from alkali halide crystals, however, few papers have been published during the past thirty years.

In earlier studies on the scattering of metal atoms from alkali halide surfaces, three types of patterns were reported; one which corresponds to specular reflection,[3] a second which obeys the cosine law,[4] and the third which is called "quasi-specular" or broad lobular pattern.[5] The results reported by different authors do not seem to be consistent with each other. Thus, more complete information on the phenomena is desiable. Concerning the technique of thin film growth on solid surfaces, work in this field might be important for clarifying the initial process of sticking of metal atoms on the surfaces.

In the present work, scattering patterns of the potassium beam from the surface of lithium fluoride were measured at several angles of incidence between 55° and 70° (measured from the surface normal). To determine the angular distribution of the flux of scattered atoms, a surface ionization detector was rotated around the target crystal. The thermal beam of potassium (cross section: 0.46 mm × 11.7 mm) was produced by effusion from an oven. Background pressure with the beam on was 2×10^{-7} Torr. Targets with lithium fluoride (001) surface prepared in different ways were used, one with a surface made by cleaving a crystal in air and the other was made optically flat by polishing with corundum powder suspended in water. The crystal was heated in a vacuum at about 470°K before it was exposed to the beam. The measurements were carried out at several temperatures from 170°K to 470°K.

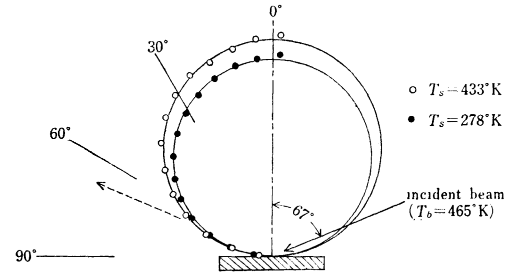

Fig. 1. Angular distribution of potassium atoms scattered from the cleavage surface of lithium fluoride (001). The solid curve indicates the cosine law. The broken line represents the specular direction. T_s and T_b are the surface temperature and the beam temperature, respectively.

Two different scattering patterns were obtained corresponding to the preparation of the surface. As is shown in Fig. 1, the spatial distribution from the cleavage surface closely follows the cosine law. This pattern indicates diffuse scattering and agrees with the results of Taylor.[4] Figure 2 shows the patterns from the polished surface. The peaks correspond approximately to the specular positions. The results give no definite conclusion but suggest that the molecules of water on the polished surface have some effect on the scattering pattern.

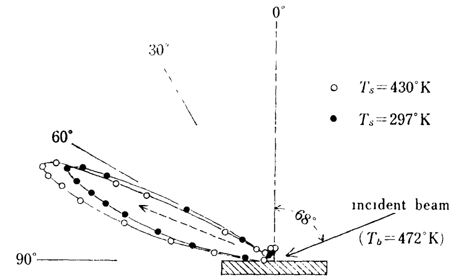

Fig. 2. Angular distribution of potassium atoms scattered from the polished surface of lithium fluoride (001). The broken line represents the specular direction. T_s and T_b are the surface temperature and the beam temperature, respectively.

Above room temperature, the scattering patterns and the scattered fluxes did not change significantly with the target temperature, while at temperatures below 250°K, the scattered fluxes decreased markedly and the patterns showed different directional features compared with those at high temperatures. The scattered flux attenuated rapidly with the time of exposure to the beam. This indicates the condensation of potassium atoms on the surface and the increase of the sticking probability. It is still difficult to explain the behavior of the two different surfaces.

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1) *Cf. e.g.* "Fundamentals of Gas-Surface Interactions," ed. by H. Saltsburg, J. N. Smith, Jr., and M. Rogers, Academic Press (1967); "Rarefied Gas Dynamics," 5th symp., Vol. 1, ed. by C. L. Brundin, Academic Press (1967); *ibid.*, 6th symp., Vol. 2, ed. by L. Trilling and H. Y. Wachman (1969).

2) *Cf. e.g.* D. L. Smith and R. P. Merrill, *J. Chem. Phys.*, **53**, 3588 (1970); A. G. Stoll, D. L. Smith, and R. P. Merrill, *ibid.*, **54**, 163 (1971).

3) A. Ellett, H. F. Olson, and H. A. Zahl, *Phys. Rev.*, **34**, 493 (1929).

4) J. B. Taylor, *ibid.*, **35**, 375 (1930).

5) R. R. Hancox, *ibid.*, **42**, 864 (1932).