

LETTERS TO THE EDITOR

AES AND LEED STUDIES OF XENON ADSORPTION ON (100)NaCl

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LEED and THEED analyses of rare gases adsorption on metals [1–7] and on graphite [8–12] show that the first adsorbed monolayer is epitaxially related to the substrate. It is out of registry (non-localized) for most metals, or in registry (localized) for xenon on copper (111) [4], krypton on graphite (0001) [10], or either, depending on pressure and temperature for xenon on graphite (0001) [11].

We report here the first results on the adsorption of a rare gas (xenon) on an alkali halide (NaCl(100)) by AES and LEED, in the same way as Suzanne et al. [8,9], in order to understand the mechanism of condensation of a non-polar adsorbate on an ionic adsorbent. This system has been first investigated by Ross and Clark [13] by a volumetric method. These authors measured three adsorption isotherms near the two-dimensional critical temperature (~ 104 K).

Our crystal is air cleaved in the (100) direction, and then heated to 200°C in ultra high vacuum during one hour in order to desorb water. This temperature is sufficiently low to prevent crystal evaporation. The topography of the air cleaved surfaces has been studied by the well known decoration technique in a transmission electron microscope. They show large flat regions separated by a few steps [14,15].

AES analysis of the clean crystal surface, at 60 K, with a primary electronic beam energy of 2.5 keV and 1.5 μA target current, does not show any surface destruction, in agreement with Bandet et al. [16] observation. Only traces of carbon and oxygen can be detected on the crystal surface. We measure the adsorption isotherm by AES and find a reversible and reproducible condensation of xenon atoms on this face; the time necessary to reach the equilibrium at low temperature and pressure is about 2 h as reported by Ross and Clark [13], which means that the sticking coefficient is very low. A stepwise isotherm is shown on fig. 1: it is typical of a two-dimensional phase transition gas \rightleftharpoons solid.

The LEED observation of the two-dimensional solid xenon ($\theta = 1$) leads to a diffraction pattern (fig. 2) with a twelve-fold symmetry (this fact has also been observed for xenon on $(1 \times 1)\text{Ir}(100)$ substrate [3]); this pattern is obtained with an electron energy of 75 eV to prevent surface charging during the experiment.

Such a LEED pattern symmetry means [3] that there are two orthogonal, approximately equally populated, pseudo-hexagonal domains of xenon in epitaxy on the (100)NaCl substrate (fig. 3). A real space representation of one of these

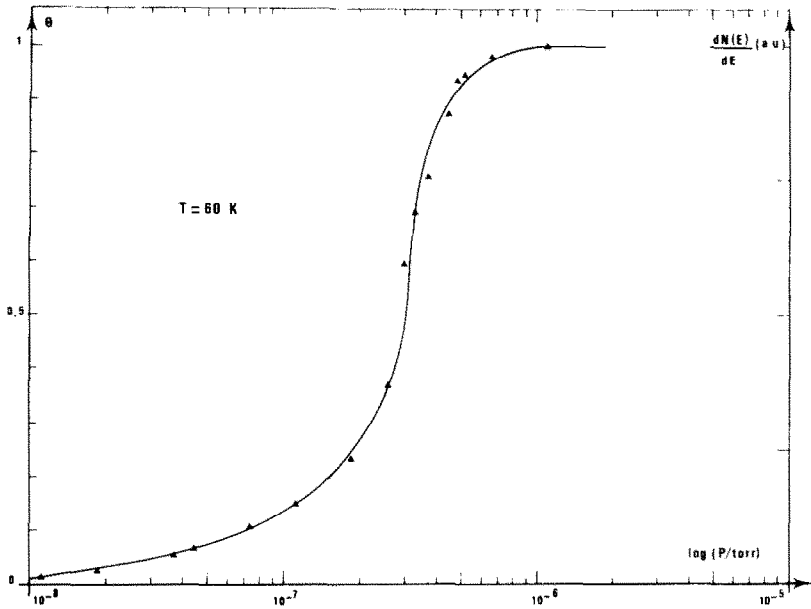


Fig. 1. Isotherm at 60 K of xenon on (100) NaCl. The pressure, given by a Varian ionization gauge, is corrected by the ionization constant of xenon. θ is the coverage ($\theta = 1$ corresponds to 5.5×10^{14} atoms cm^{-2} , obtained by LEED interpretation, figs. 3 and 4). $dN(E)/dE$ is the peak-to-peak height of xenon transition at 40 eV.



Fig. 2. Diffraction pattern of a xenon monolayer on (100)NaCl at 60 K and 1.1×10^{-6} Torr; the incident energy is 75 eV.

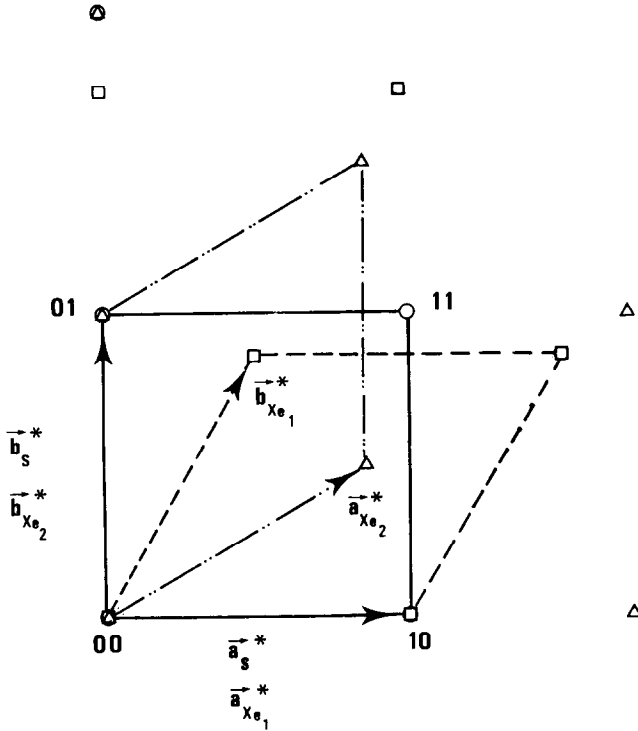


Fig. 3. Interpretation of the diffraction pattern: (○) substrate spots; (◻) first pseudo hexagonal xenon domain spots; (△) second pseudo hexagonal xenon domain spots.

domains is given on fig. 4. Xenon atoms are non-localized with respect to the four-fold symmetry sites. The overlayer is one-dimensionally ordered in the [010] direction. Fig. 2 shows that the reciprocal lattice parameter a_{xe}^* , of xenon, is approximately equal to a_s^* , the reciprocal lattice parameter of the unit cell of (100) NaCl. Since the substrate is an fcc crystal, one has

$$a_s^* = 1/a_s, \tag{1}$$

where a_s is the lattice parameter of NaCl. Besides, the adsorbed xenon unit cell is hexagonal and

$$a_{xe}^* = 2/a_{xe}\sqrt{3}, \tag{2}$$

where a_{xe} is the crystal lattice parameter of the xenon monolayer.

Combining (1) and (2) gives:

$$a_{xe} = 2a/\sqrt{3}$$

Taking a lattice parameter of 3.98 Å for the unit cell of the NaCl(100) plane, we

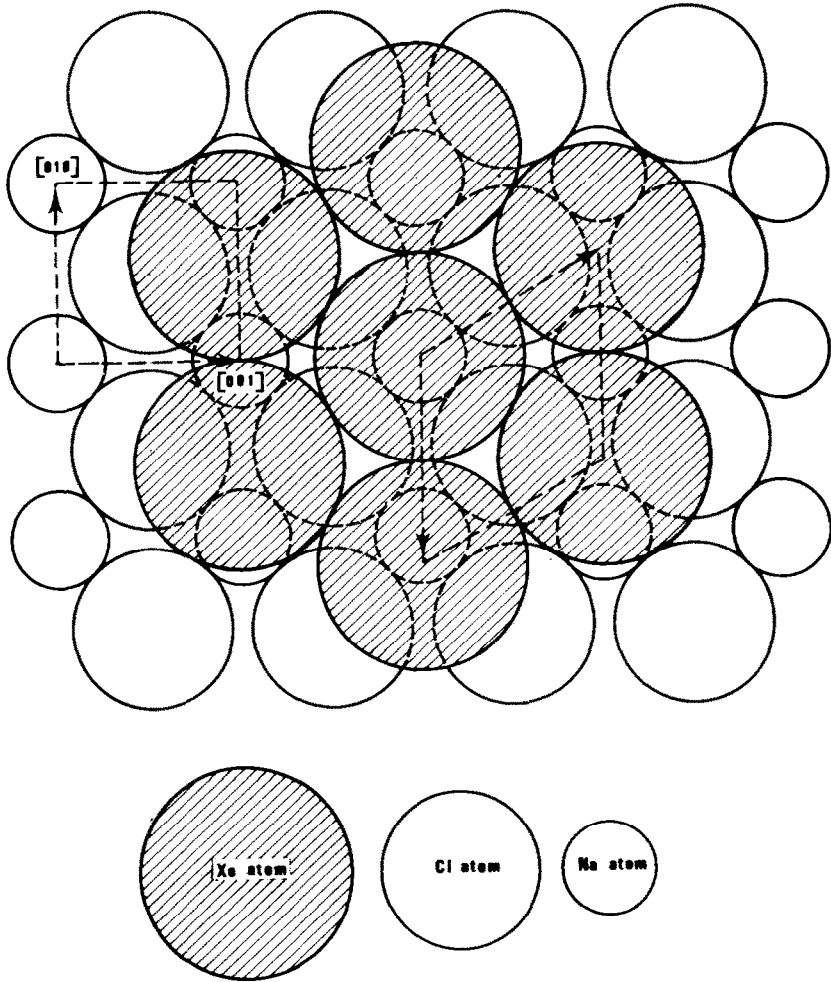


Fig. 4. Adsorption model of xenon on (100)NaCl.

deduce a xenon–xenon spacing of 4.6 Å; therefore, the two-dimensional solid xenon should be expanded of 5% with respect to the fcc (111) xenon plane at the same 60 K temperature.

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