Light-induced adsorption on dielectric surfaces of alkali atoms from a thermal vapour

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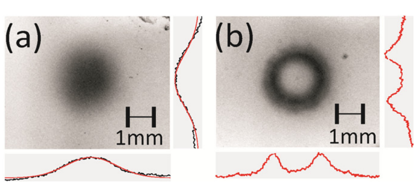
The interaction of light with thermal alkali vapours in optical cells has been the subject of numerous studies. The interaction between the atoms and the cell walls plays an important role in some experiments, essentially because of spin depolarization and surface conductivity. The presence of light alters the atom - surface interaction by inducing desorption and diffusion and thus allows one to modify those processes and to devise applications, such as control of atomic density through light-induced desorption [1]. Control of the adsorption process using light has recently been achieved [2], by sending a near resonant cw laser at the interface between a dielectric and an alkali vapour. However, the physical process underlying this phenomenon needs further investigation.

Here we describe an experimental investigation of light-induced adsorption and fully explain its mechanisms. We use a laser beam resonant with the Cs D2 line to grow a light induced metallic Cs film at the interface between the vapour and the cell surface, at a typical rate of 10^{-1} nm/min. This rate varies linearly with atomic density and cubically with the pump beam intensity. It exhibits the same frequency dependence as the Cs D2 fluorescence. There is an atomic densities threshold which prevents observing the light-induced film for low density.

From these observations, we identify the light induced film growth mechanism as the adsorption of laser-produced Cs ions. The ions are formed by two-photon absorption from the first excited level of Cs atoms. However, the ions must be neutralized on the surface to grow a multilayer film. On the one hand, the probability of ions neutralization depends on the relative electronegativities of the ions and the surface. On the other hand, the electronic properties of the surface depend on the number of neutral atoms adsorbed before the ions are produced. Particularly, the work function of a clean surface may decrease by a few eV when covered with a fraction of a monolayer of adsorbed alkali atoms. The atomic density threshold is thus a surface coverage threshold, above which the surface work function is sufficiently lowered so as to guarantee ions neutralization.



The spatial profile of the film formed on the surface follows the laser beam profile, thus allowing patterns to be drawn (Fig. 1). The control of the number of adsorbed atoms with light might be used to finely tune the surface work function, which is important, for instance, to control the efficiency of surface electron emission.

Figure 1: The spatial profile of the light-induced metallic film follows the laser beam intensity profile: a) a Gaussian beam b) a ring-shaped beam.

References:
[1] A. Hatakeyama, W. Wilde , K. Fukutani, e-Journal of Surface Science and Nanotechnology **4**, 63 (2006).
[2] A. Afanasiev, P. Melentiev, V. Balykin, JEPT Lett. **86**, 172 (2007).