

Vibrational Mechanism of the Latent Image Speck Formation

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Abstract

The disbalance of the theory and experimentally established properties of the silver halide photographic materials was considered and a conclusion on the existence at least three mechanisms of the latent image speck formation was drown: conventional Gerny-Mott mechanism and two another ones - vibrational and dislocational. The experimental verification of the vibrational mechanism was fulfilled with the impulse laser optoacoustic method on the photographic materials under careful control. The period of the latent image speck formation found to be as short as 2.10^{8} sec^{-1}. No evidence of the electron-hole pairs generation was established under experimental conditions. The mechanism of the optoacoustic effect was purely thermal.

Introduction

The Herny-Mott theory does not explain a few rather important experimental facts. For instance, the silver halide photographic materials are sensitive to ultrasound [1,2]. Initially, it was supposed that ultrasonic sensitivity is due to the flashes accompanying cavitations [3]. Nethertheless, this idea was refuted since direct action of the ultrasound on the photographic film was proved experimentally [4,5].

It was shown [5], that blackening of the photographic materials occurs at the antinodes of standing ultrasonic waves, but there are no latent image specks at the nodes of the same waves. This is a clear demonstration of the influence that the amplitude of acoustic vibrations has on the formation of latent image specks. No theoretical explanation of this phenomenon was offered.

An important experimental fact was described by Bennet [5]: the efficiency of ultrasonic vibrations depends on the degree of gelatin plasticity. If the gelatin is dry, the temperature is low, and so is the power of the ultrasonic generator, then the acoustic waves produce no effect on photographic materials. But after the gelatin is plasticizide by moistening or heating, ultrasonic waves easily form latent image specks.

Another experimentally observed fact which has no explanation in the framework of Herny-Mott theory is the increase of the sensitivity of photographic emulsions when surfactants are added to the emulsion. Fluorinated surfactants are approximately twice as effective as hydrocarbons [7]. No explanation is offered for such increase in sensitivity. Molecules of the surfactant desorb gelatin from the surface of the silver halide crystals and become adsorbed on them, affecting neither the electronic nor ionic properties of AgHal.

Taking into account the migrations of the silver clusters around the surface of AgHal-microcrystals immersed in gelatin and trapping of these clusters by the emergencies of dislocations the vibrational mechanism of the latent image speck formation was proposed as the following. Silver halide crystals have definite phonon spectra at room temperature. It is reasonable to believe that in this case the amplitude and spectrum of lattice vibrations do not meet the requirements under which silver clusters migrate over the surface of the AgHal crystals coated with gelatin. However these vibrations are close to the required conditions. By virtue of the ultrasonic vibrations or optoacoustic effect, when light quanta absorbed by the silver halide crystals generate elastic waves, the acoustic spectrum becomes richer and the amplitude of vibrations sufficiently large to cause migration of silver clusters and their aggregations in the traps, that leading to the latent image speck formation.

The surface AgHal crystals is depleted in silver ions first at emergence point of dislocations, thus these points have negative charge. On the other hand there is no doubt that gelatin adheres to the AgHal surface at points with maximum adsorption energy: at emergence point of dislocations. Attachment of the anionic surfactant to them instead of gelatin is less probable than to the neutral gelatin. Therefor, anionic surfactants liberate emergence points of dislocations which are traps for migrating silver clusters.

Hydrocarbon surfactants undergo strong hydrolysis so neutral molecules (acids) occupy partly the emergencies of dislocations. Fluorinated surfactants are hydrolyzed considerably less, and consequently, they are absorbed predominantly in the anionic form outside of the emergencies of dislocations. So the later are more efficient as the traps of the silver clusters.

Experimental

The emulsion with tabular microcrystals AgBr doped with 4.5% of iodide was used. The sulfur sensitization was applied to produce photosensitivity 50 and 170 ASA units in the contrast to original value 0.85. The dye sensitizer improved the light absorption of Nd:YAG laser second harmonics radiation. The emulsion was deposited on a glass plate support; the content of silver was 4 g/m^2 recounting to metallic silver. The averaged dimensions of AgBr crystals across a plate was about 1 μm; the average distance between crystals was 2-3 μm. The description of optoacoustic instrumentation is described somewherelse [8,9].

Thermal mechanism of the optoacoustic effect was observed. No evidence of concentration-deformational mechanism was recorded. Hence the electron-hole pairs and their life-time was either shorter than 2.10^8 sec^{-1} or was absent at all.

The selfdiffusion of silver clusters initiated by optoacoustic effect formed the latent image specks: the development of photographic plates in standard developer at room temperature during 3 minutes produced the optical density D = 1.5.

Conclusions

This experiment demonstrates that the latent image specks can be formed due to vibrational mechanism, i.e. aggregation of the silver clusters at the points of the emergency of dislocations in the course of selfdiffusion generated by optoacoustic effect.

However, both Herny-Mott and vibrational mechanisms do not cover the diversity of processes leading to the formation of the latent image specks. For instance, it is known that in the case of strong deformation of the photographic film of in the case of impact development centers are formed.

Mechanical stress in silver halide crystals generates dislocations, whose emergence points migrating over the crystal surface can gather silver clusters; larger aggregates are produced upon mutual collisions, resulting in the formation of developable centers. Such mechanism can be called dislocational.

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