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Solarization nature on the etched microcrystals of silver bromide

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ABSTRACT

The creation on solarization the great crystalline latent image centers on the surface of AgBr microcrystals etched by the solution of sodium thiosulfate was analyzed. It was indicated that voltage potential $E \approx 10^2$ V/sm of the infrared pulsed laser light $\lambda = 850$ nm, with the power P = 4 watt in an impulse $2\cdot10^{-7}$ seconds resulted in the etching pits. The field influences the creation of the great latent image centers.

KEYWORDS

Latent image center;
Laser light;
Etching pits on the surface of AgBr microcrystals;
Solarization.

INTRODUCTION

Metallic nanoparticles have unique optical, electrical and biological properties that have attracted significant attention due to their potential use in nanodevice fabrication biotechnologies and for curing cancer. Today, transmission electronic microscopy is widely used for silver nanoparticles studying. It is the modern research method due to its high-resolution capacity and the electron diffraction applied in electron microscopy. Properties of silver nanoparticles depend on the surface of solid-state AgBr microcrystals where they appear.

On exposure of films by the white light being in large excess over those getting a negative picture we can observe the decrease of optical density D of the developed photolayer. This effect is called a photolayer solarization. Solarization can be applied for getting positive images in ones showing by the white light[1]. Preetching (before exposure) in photoemulsion with solvents of AgBr microcrystals leads to solarization increasing in comparison with nonetched AgBr microcrystals. Solarization is more complicated physical process than the Herschel effect. In the paper[2] it was underlined that on solarization on the etching surface of AgBr microcrystals greater in size developed latent image centers in etching pits in the forms of silver cubic, or hexagonal prisms were created. It was possible with the help of the electron microscopy.

Solarization nature on microcrystals of silver bromide etched by aqua solution $Na_2S_2O_3\cdot5H_2O$ is of some interest.

RESEARCH TECHNIQUE

With the help of the sensitometric method we determined the conditions for getting solarization on an etching and developing photolayer. With the help of the electron-microscopic method we researched latent image centers raised on the surface of the etched undeveloped AgBr microcrystals in the case of solarization.

Photolayers SP-1 with 6 units GOST sensitivity and photolayers SP-III with 4 units GOST sensitivity are investigated. To get latent image centers on solarization before the illumination by the white light a photolayer was put in darkness into 50% aqua solution of sodium thiosulfate ($Na_2S_2O_3{\cdot}5H_2O$) with the concentration 125 g/l for 90 seconds. Aqua solution of sodium thiosulfate was paddled with a soft rubber brush on the surface of the photolayer. After being etched AgBr microcrystal was washed with distilled water, baked in darkness in the dustproof and shadowed place. Then it was exposed during 1 second, 2 seconds, 3 seconds, 4 seconds by the while light in sensitometer ФСР-41 via the optical wedge, and undeveloped sensitograms on the photolayer were obtained.

Photolayer development took 240 seconds in the Chibisov's developer at a temperature $293 \pm 0{,}1$ K. Optical density D was measured with the microphotometer МФ-2 after being developed and fixed. Characteristic curves (Figure. 1) with the help of which the solarization existence domain for small expositions 1-4 seconds and small D were calculated.

Native AgBr microcrystals etched by sodium thiosulfate were taken out of photoemulsion for electron microscope investigation. They were applied on the clean glass plate. After drying in darkness the plate with AgBr microcrystal was deposited over the area of the optical wedge of the sensitometer where the peak solarization took place. The area was indicated with the help of characteristic curves. The plate with AgBr microcrystal was dipped into 1% collodian liquid in amylacetate. In such a way collodion replicas with AgBr microcrystals were prepared. Those replicas did not tone with carbon. Before and during the work of an electronic microscope they were chilled down with liquid nitrogen. Photography replicas of AgBr microcrystal was made with the electronic microscope BS-613 of the firm "Tesla" with resolution not worse than 4,5 Å.

The etching pits appear on etching by 50% aqua solution of sodium thiosulfate on the surface of AgBr microcrystals. In papers[4] it was fixed that etching pits were in dislocation exit points. They can have different sizes, and they depend on the solvent strength, the solvent temperature, the duration of etching, crystal symmetry.

Ionic crystals NaCl and AgBr have point symmetry group m3m[4,5]. Thus, etching pits as a rule are in the form of cubic deepenings. On the flat sides of etching pits there are unbalanced electric charges[4], which can lead to the latent image centers.

EXPERIMENTAL RESULTS AND DISCUSSION

Characteristic curves of the layer (SP-III, 4 units) etched during 240 seconds by 50% aqua solution $Na_2S_2O_3{\cdot}5H_2O$ before being exposed by the white light during 1 second (1), 2 seconds (2), 3 seconds (3) and 4 seconds (4) are shown in Figure 1.

Electron microscopic picture of a native undeveloped AgBr microcrystal is shown in Figure 2. There are etching pits on its surface after having being etched during 90 seconds by 50% aqua solution of sodium thiosulfate ($Na_2S_2O_3{\cdot}5H_2O$) with the concentration 125 g/l.

Electron microscopic picture of collodion replica from the undeveloped AgBr microcrystal having being etched during 2 minutes by 50% aqua solution of sodium thiosulfate ($Na_2S_2O_3{\cdot}5H_2O$) with the concentration 125 g/l is shown in Figure 3. For partial etching of a photolayer the solution of sodium thiosulfate with 50% concentration out of the standard fixage 250 g of $Na_2S_2O_3{\cdot}5H_2O$ for 1 liter of distilled water was used. The duration of exposition by the white light was 4 seconds. Great latent image centers in the form of hex right and cubic prisms were evident.

Via the scale of magnification (Figure 3) we have determined that crystalline latent image centers on solarization have the size of 210 nm. It is consistent with the sizes of latent image centers got for the solarization area in the paper[6].

There are cubic etching pits of different sizes in Figure 2.

In Figure 1 magnitudes for making Figure 4 are taken.

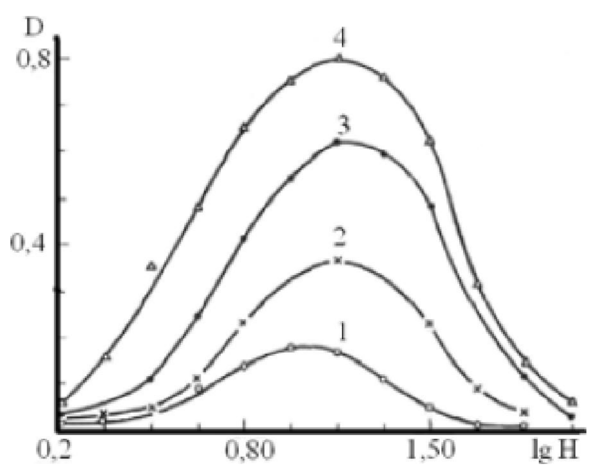

Figure 1

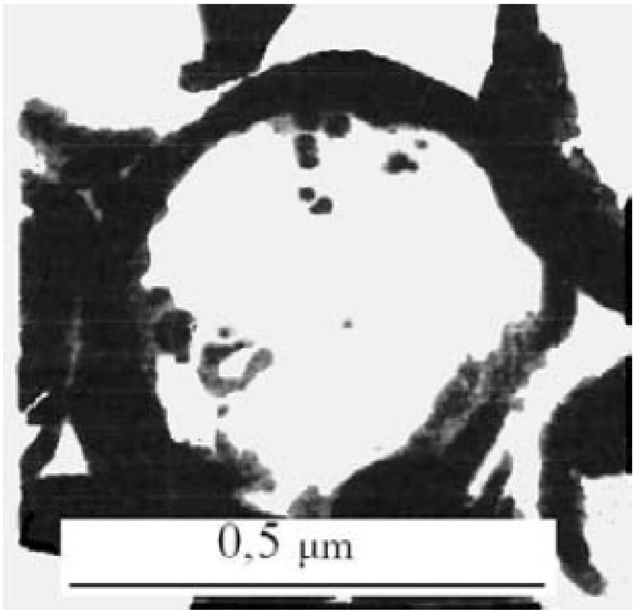

Figure 2

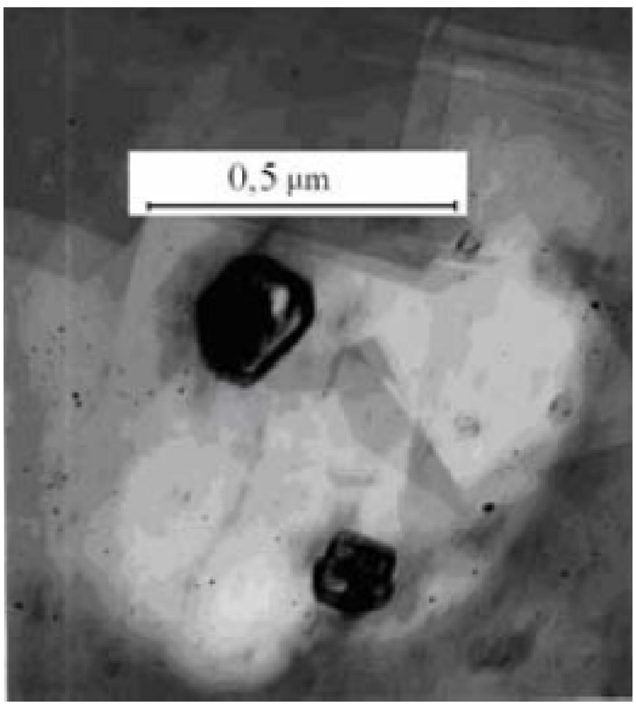

Figure 3

The results given in Figures 2 and 3 can be explained by the fact that cube sides of etching pits (type 2) for AgBr microcrystals consist of Ag^+ ions. Ag^+ ions on the sides of etching pits have free unbalanced bonds. Photoelectrons having got as a result of AgBr microcrystals expansion by the white light can get into etching pits and make with Ag^+ ions neutral silver atoms. It will lead to the creation of latent image centers in etching pits[4].

There is an electrical field by the microcrystal surface. There are different voltage potentials 0,2 volt in photoemulsion on the surface of AgBr microcrystals. But as the potential fall takes place in small distance (AgBr microcrystals in photoemulsion SP-1 with 6 units GOST sensitivity have the size ~ 1 µm) there is an electrical field with strength $E = 2{\cdot}10^3$ V/sm. That electrical field appear at the cost of charged electric dislocations of AgBr microcrystals with high level of defects. That field facilitates photoelectrons movement to etching pits of AgBr microcrystals. Taking into consideration the scale magnification shown in Figure 3 we can calculate a side of

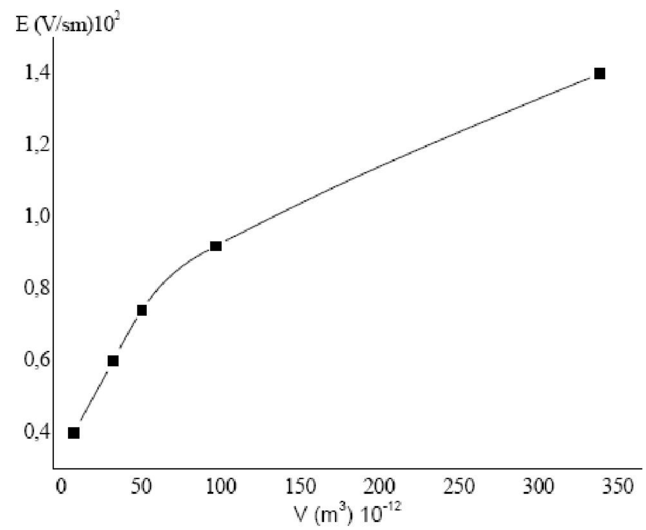

Figure 4 : Dependence of voltage potential in etching pits on the volume of latent image centers in the sepits created on solarization.

TABLE 1

№	Laser wave length (nm)	Pulse laser capacity (Watt)	Deep of cubic etching pit $\cdot 10^{-6}$ (m)	Volume of latent image center in cubic etching pit$\cdot 10^{-12}$ (m^3)	The electric field strength in etching pit 10^2 (V/sm)
1	850	4	0,02	8	0,4
2	850	4	0,032	32,7	0,6
3	850	4	0,037	50,6	0,74
4	850	4	0,046	97,3	0,92
5	850	4	0,0697	338,6	1,4

the cubic etching pit, $в$ = 0,0697 μm. Due to the data in paper[3] we can determine strength of electrical filed E = $(0,0697 \cdot 10^{-6}$ m $\cdot 2 \cdot 10^{3}$ V/sm) : $1 \cdot 10^{-6}$ m = $1,4 \cdot 10^{2}$ V/sm for the cubic etching pit in its deep $в$ = 0,0697 μm. For etching pit in hexagonal latent image centers we in the same way can also evaluate that E=$3,5 \cdot 10^{2}$ V/sm. Thus, greater etching pit has greater strength of electrical filed and greater latent image center created on solarization.

In the paper[7] the formula for determining strength of electrical filed in the laser beam $E=(4 \cdot P/(\pi \cdot \varepsilon_0 \cdot c \cdot d^2))^{1/2}$ (where P is laser power in impulse during $2 \cdot 10^{-7}$ seconds, d is the diameter of the laser beam, ε_0 is dielectric constant, c is light velocity) was derived. Nature of the normal Herschel effect and solarization is coagulative[8,9]. Inserting into the formula the laser power P= 4 watt, $\varepsilon_0 = 8,85 \cdot 10^{-12}$ C/V·m light velocity c = $3 \cdot 10^{8}$ m/s when the normal laser Herschel effect takes place we get the magnitude of strength of electrical filed in the laser beam E = $4,4 \cdot 10^{2}$ V/sm. On focus of the laser ray while Herschel effect up to the diameter d = 0,1 sm we get strength of electrical filed in the laser beam E = $4,4 \cdot 10^{2}$ V/sm. Due to magnitudes $1,4 \cdot 10^{2}$ V/sm $\approx 1,1 \cdot 10^{2}$ V/sm; $3,5 \cdot 10^{2}$ V/sm $\approx 4,4 \cdot 10^{2}$ V/sm strength of electrical filed in etching pits on solarization on the etched AgBr microcrystals and in the laser beams are the same for calculation an experimental normal Herschel effect.

The creation of great crystal latent image centers on solarization in cubic and hexagonal forms is correlated with papers[10,11,12]. In the paper[10] it was theoretically indicated that there were great crystal latent image centers of cubic and hexagonal forms on solarization. It is correlated with our experiments shown in Figure 3.

CONCLUSION

Strength of electrical filed E = 10^{2} V/sm taking place in etching pits influences the creation of great crystalline latent image centers on the surface of AgBr microcrystals etched by 50% aqua solution of sodium thiosulfate ($Na_2S_2O_3 \cdot 5H_2O$) in photoemulsion E $\approx 10^{2}$ V/sm with 6 units GOST sensitivity.

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