Photoelectron time-resolved spectra of silver halide microcrystal adsorbed with spectral sensitizing dye

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Microwave absorption and dielectric spectral detection technology with high time resolution (1 ns) is used for contactless measurement of electron property in solid materials. In this paper, the free photoelectron time-resolved spectra of cubic AgCl emulsion sensitized by green-sensitizing dye are measured by dielectric spectral equipment. The samples are exposed to 35-ps short pulse laser at 355 and 532 nm, respectively. The results show that for the same sensitized sample, the free photoelectron lifetime are 43.1 and 5.8 ns, respectively. And for the same wavelength, the lifetime of sensitized emulsion is shorter than that of pure emulsion. It is thus proved that the adsorption of dyes to silver halide microcrystals increases the Ag_i^+ concentration.

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The spectral sensitization technology is important to modern photographic industry. Many researchers paid more attention to the study of spectral sensitizing mechanism. The photoelectron is the foundation of latent image formation of silver halide, so study of the decay process of photoelectron is a key to reflecting the photosensitive property. Müssig[1] measured the photoelectron time-resolved spectra of silver halide emulsion with microwave absorption and dielectric spectral detection technology, and studied the influence of spectral sensitizing dye on the lifetime of photoelectron in cubic grains. Yang *et al.*[2] found that when the samples were adsorbed with spectral sensitizing dye, the lifetime of free photoelectron in silver bromine emulsion decreases. However, the laser wavelength used for exposing samples is only limited at ultraviolet area (355 nm) which is the intrinsic absorption wavelength area of silver halide microcrystal. But the absorption peak of spectral sensitizing dye is at 532 nm. So the photoelectron decay property of sample which is exposed at absorption peak of spectral sensitizing dye (532 nm) is more important to the study of spectral sensitizing mechanism.

In this paper, we obtained the photoelectron decay curves of cubic AgCl microcrystals adsorbed with spectral sensitizing dye. The samples were exposed to 35-ps short pulse laser at 355 and 532 nm, respectively.

The principle of microwave absorption dielectric spectrum equipment has been shown in Ref. [3]. A film sample is inserted into a microwave cavity at the position where the electric field is a maximum and is exposed by 35-ps YAG pulse laser. Because of free electron are generated in the sample, the susceptibility tensor are changed. The change of the complex susceptibility is detected as the power absorption of the sample. By detecting the absorption signal, the photoelectron decay characteristics were found. The 35-ps YAG pulsed laser is applicable. Wavelength is 355 nm. The signals are displayed by a digital storage oscilloscope (Tektronix-TDS3052, sampling rate 1 G/s).

The cubic AgCl grains (0.4 μm) prepared by double-jet method are sensitized by green sensitizing dye. The sensitization concentrations is 6 mg/40 g AgCl emulsion, the adsorbing temperature and adsorbing time of dye are respectively 45 °C and 30 minutes. The structure of dye used is shown in Ref. [3].

Figure 1 shows the comparison of free photoelectron decay curves of pure and dye-sensitized cubic AgCl emulsion. The exposing wavelengths are 355 nm in Fig. 1(a) and 532 nm in Fig. 1(b). Curves 0 and 1 represent the photoelectron decay of pure and dye-sensitized AgCl emulsion, respectively. The absorption of pure emulsion is very weak at 532 nm, so the photoelectron time-resolved spectrum is not obtained in our experiment (no curve 0 in Fig. 1(b)). The signals of the free photoelectrons are exponential decay curves. The free photoelectron lifetime is estimated from semi-logarithmic plot (see

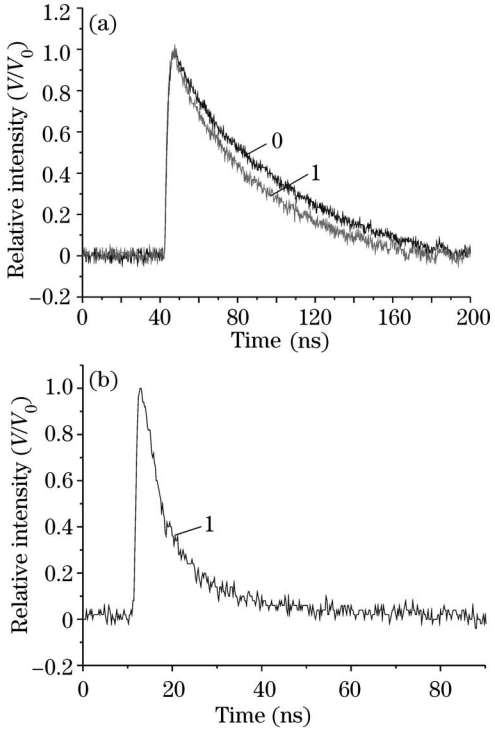

Fig. 1. The free photoelectron decay curves of pure and dye sensitized cubic AgCl emulsion with the laser wavelengths of 355 nm (a) and 532 nm (b).

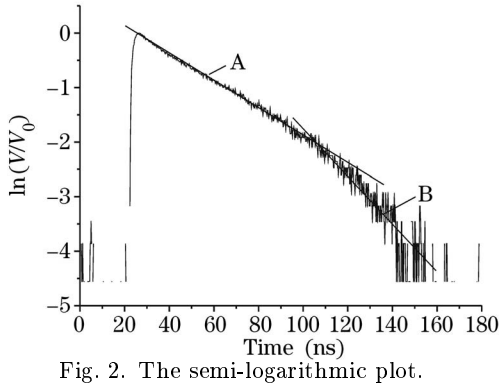

Fig. 2. The semi-logarithmic plot.

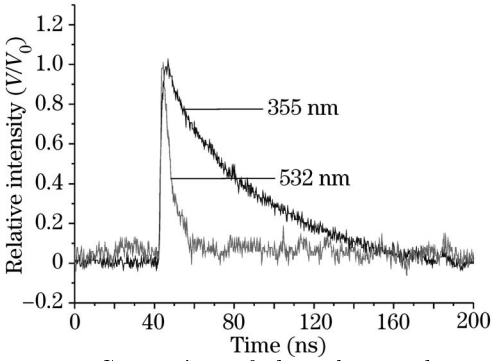

Fig. 3. Comparison of photoelectron decay.

Table 1. The FDTs and FLTs with Different Exposing Wavelengths

Curve	Wavelength (nm)	FDT	FLT (A)
0	355	113.0	55.0
1	355	90.5	43.1
	532	12.2	5.8

Fig. 2). It can be seen from Fig. 1 that the free photoelectron decay of dye-sensitized cubic AgCl is faster than that of pure cubic AgCl, no matter the laser wavelengths are 355 and 532 nm. Figure 3 shows a comparison of free photoelectron decay curves of dye-sensitized cubic AgCl exposed at 355 and 532 nm. The free photoelectron decay time (FDT) and free photoelectron lifetime (FLT) are shown in Table 1.

It is can be concluded from the above results that the spectral sensitizers increase the concentration of Ag_i^+, which accords with the result of dielectric loss measurement[4,5] that the adsorbed dyes increase the ionic conductivity.

For the same sample, the silver halide absorbs light but the sensitizing dye nearly does not absorb light at 355 nm. The AgCl exchanges to Ag^+ and Cl^- and the free photoelectrons are produced after absorbing light. However at 532 nm, the silver halide nearly does not absorb light but the sensitizing dye absorbs light. The photoelectrons in excited state are produced. As a result of the two progresses, photoelectrons are detected in the silver halide, but the decay property is different. So it is can be concluded that when the sample is exposed at 532 nm, the free photoelectrons are transferred from the sensitizing-dye, which provides an indirect evidence for the electron transfer theory.

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