

Influence of Iodide Distribution on the Kinetics of Photocharge Carriers in Tabular Crystals

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Abstract

The extremely high speed of silver halide emulsions is achieved by the incorporation of phase boundaries into the emulsion grains. Today the application of this technology has reached a high level of perfection which results in silver halide microcrystals of complicated structures like core-shell or multistructured grains.

Phase boundaries between regions of different halide composition in, for example, core shell systems with iodide containing shells have a strong influence on the electron-hole recombination rate and various other trapping and detrapping processes. Therefore there is a need for optimised iodide incorporation conditions and for an understanding of the influence of iodide distribution on photocharge carriers.

We studied the effect of various iodide incorporation methods and selected shell structures on the kinetics of photocharge carriers. A discussion together with the grain defect-structures induced by the high iodide phases, low temperature photoluminescence measurements and a comparison to the sensitometric data gives further insights.

Introduction

CN-film emulsions are often designed as thin multishell (111)-Ag(Br,I)-tabular crystals. Usually the shells of the tabular crystals differ in size and iodide content and may be precipitated by a variety of methods for iodide incorporation during crystal growth. The purpose of this investigation was to test the influence of the iodide distribution and the iodide incorporation method on the physical qualities of thin (111)-Ag(Br,I)-tabular grains.

Experimental

A variety of multishell (111)-Ag(Br,I)-tabular crystals with systematic changes in iodide distribution and shell sizes have been precipitated as told in [1,2]. Additionally different iodide incorporation methods described in [3] have been used. The crystals used in this investigation have an

AgBr-core followed by an inner shell with low iodide concentration. Another iodide containing shell with a high iodide concentration is located under the final AgBr-shell. The precipitated emulsions are classified by the amount of iodide in mol% referred to the whole crystal located in the low-iodide shell or high-iodide shell, respectively and by the size of the final AgBr-shell in mol% of the total precipitated silver in table 1.

Table 1: Iodide concentration for the different iodide zones

Crystal structure	Iodide Concentration mol %	
	Low iodide zone	High iodide zone
Low and high iodide zone	10	40
Low iodide zone	10	0
High iodide zone	0	40

Results

Dislocations

Tab. 2 gives the information about the dependence of the dislocation structure on the inner iodide structure of the emulsion crystal. The dislocations are classified like introduced in [3] as crystals without dislocations, with a limited number of dislocations or with a network of dislocations.

Table 2: Dislocation structure in dependence of the iodide zones

I-Zones	Dislocation lines		
	No	Limited number	Network
Low iodide High iodide	9 ± 5 %	45 ± 9 %	45 ± 9 %
Low iodide High iodide	64 ± 6 %	32 ± 6 %	4 ± 2 %
Low iodide High iodide	16 ± 5 %	44 ± 7 %	40 ± 7 %

The table shows, that in case of crystals with only a low iodide zone a low number of dislocations has been found while in case of high iodide zones a network of dislocations can be formed.

Low Temperature Photoluminescence

The different crystal structures were characterised with Low Temperature Photoluminescence (LTPL). The measurements have been done for a temperature of 20 K and an excitation wavelengths of 350 nm. From the literature it is known [4] that with an increasing size of (AgI)_n-clusters the wavelength of the luminescence peak shifts to higher values. The peak position of the luminescence for the low iodide zone with 548 nm and for the high iodide zone with 580 nm indicates, that the high iodide zone leads to a bigger sized (AgI)_n-clusters in comparison to the low iodide zone.

Dielectric Loss Measurements

To get information about the ionic conductivity dielectric loss (DL) measurements are performed. The results are given in Tab. 3. The ionic conductivity is proportional to the interstitial silver concentration .

Table 3: Ionic conductivity in dependence to the iodide zone. The conductivity is proportional to the frequency F_{max} . I_{ges} is the overall iodide concentration

I-Zone	I_{ges} /mol %	F_{max} (KHz)
Low iodide	6,5	398
High iodide	2,5	200
Low iodide	4,0	398

High peak frequency means high ionic conductivity and therefore high interstitial silver concentration. The DL data in Tab. 3 show, that for the low iodide zone the lowest interstitial silver concentration was measured. Obviously the interstitial silver concentration is strongly influenced by the high iodide zone.

Microwave Absorption Measurements

Investigations were done on the dependence of electron lifetime on the grain structure with microwave absorption (MA) measurement.

Fig. 1 and 2 show two typical photoelectron decay curves for the examined grain structures.

The photoelectron decay curves for a low iodide zone presented in Fig. 1 are discussed in detail by [5,6]. The curve can be separated in 3 parts for the electron lifetime.

- τ_1 - quick photoelectron decay
- τ_0 - photoelectron trapping in very shallow traps

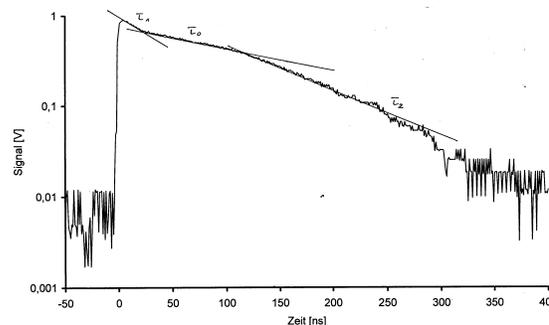


Figure 1: Photoelectron decay curve for a low iodide zone

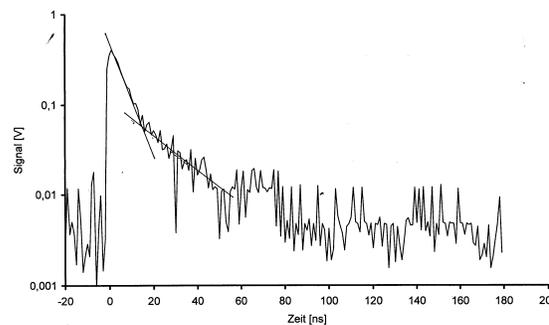


Figure 1: Photoelectron decay curve for a high iodide zone

τ_2 - photoelectron trapping in deep traps

The photoelectron decay for high iodide zone has a significant other characteristic in comparison to the decay curve for a low iodide zone (see Fig. 2)

1. There is no trapping of photoelectron in a very shallow trap
2. τ_1 is really 8 times and τ_2 is 3 to 4 times smaller.

The combination of both gives the same electron lifetime τ_2 , whereas τ_0 is valid and τ_1 is doubled in comparison to crystals with the high iodide zone only (see table 4).

Table 4: Photoelectron lifetime in dependence of the iodide zones

I-Zone	t_1 /ns	t_0 /ns	t_2 /ns
Low iodide	16		63
High iodide	60	150	70
High iodide	8		20

A discussion of these results and the influence of the overall iodide concentration in the emulsion crystals will be presented.

References

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