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LIGHT INDUCED RECOVERY OF EL2 DEFECT FROM THE METASTABLE CONFIGURATION*

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The measurements of changes in a magnitude of EL2 characteristic infrared absorption were used to investigate a phenomenon of light induced recovery of the defect from its metastable state in semi-insulating (SI) and n-type GaAs. At a temperature of 12 K illumination with photons of energy 1.45 eV caused partial recovery for both SI and n-type samples. For n-type samples partial recovery occurred also after irradiation with photons of energy lower than 0.73 eV.

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During recent decade EL2 defect in GaAs has been one of the most intensely investigated defects in semiconductors. The presence of an optically induced metastable configuration is the most puzzling feature of this defect. The metastable state is reached when a cooled sample is illuminated with photons in the range of 1–1.3 eV [1]. For some time it has been commonly accepted that the only way for the EL2 to return from metastable to ground state configuration is thermal recovery occuring when the sample is heated to approximately 40 K for n-type and 120 K for SI type of GaAs. Recently, it has been reported by several authors that the recovery process can also be induced by illumination of a sample with photons in the range of 0.7–1.5 eV. In the Table a summary of these data is reproduced after Manasreh et al. [2].

There are considerable discrepancies in the magnitude of the efect observed by different authors. It is not clear whether these discrepancies are due to a different method of detection, experimental conditions or a sample used. Most of the results were obtained at liquid nitrogen temperature which is considerably higher than the temperature at which the recovery process occurs at presence of free electrons in n-type sample. At 77 K light induced recovery of EL2 in SI sample may

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then be due to thermal process while photons merely creates sufficient free electron concentration. The conditions at which the recovery process was observed at lower temperatures are in turn not clear. For example Tajima [4] reports 100% recovery at liquid helium temperature under illumination by YAG laser while photons with the same wavelength are known to produce opposite effect (e.g. quenching of EL2 to the metastable state) as well. To clarify some of the issues in the presented work the measurements on samples with different electron concentrations were performed under comparable experimental conditions using an unambiguous method to establish the variation of concentration of EL2 in its doubly occupied ground state $EL2^0$.

Experiments were perfomed on n-type Bridgman grown GaAs with free electron concentration $10^{16}\,cm^{-3}$ containing $3 \times 10^{16} cm^{-3}$ EL2 and SI Czochralski grown GaAs containing $10^{16}\,cm^{-3}$ $EL2^0$. The $EL2^0$ concentration was monitored by measuring absorption spectrum in the region from 0.8 to 1.5 eV. The measurements were made using a Cary 17 spectrophotometer. The irradiation was provided using halogen lamp and interference filters or a filter transmitting photons with energies lower than 0.7 eV made from a polished germanium wafer. Reference spectra were recorded after the sample was cooled in the dark to 12 K and after EL2 was fully quenched to a metastable configuration by illumination during 30 minutes with white light. Then temperature of the sample was set to desired value and the sample was irradiated with photons of selected energy for different periods of time. After the irradiation the spectrum was again recorded and compared to the spectra obtained before and just after the initial quenching.

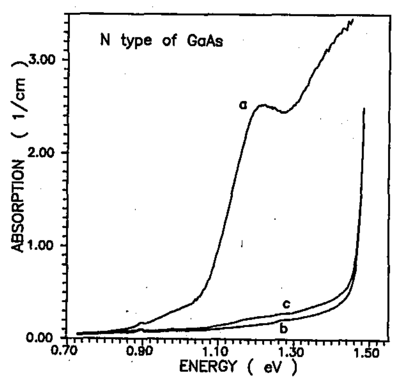

Fig. 1. The influence of 1.45 eV illumination both for SI and n-type of GaAs; (a) initial spectrum after cooling in dark, (b) spectrum after quenching to metastable state, (c) after 30 minute 1.45 eV irradiation.

At 12 K both for n-type and SI samples after illumination with 1.45 eV photons recovery with similar rate was observed (see Fig. 1). The rate was strongly increasing when the temperature was raised. The recovery under illumination at 0.8 eV was not observed. In n-type GaAs partial recovery was observed after irra-

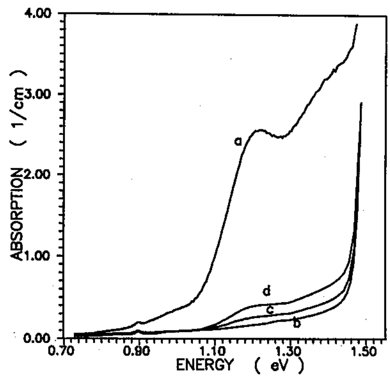

Fig. 2. The influence of photon irradiation lower than 0.73 eV for n-type of GaAs; (a) initial spectrum after cooling in dark, (b) spectrum after quenching to metastable state, (c) after 1 hour photon irradiation (energy lower than 0.73 eV), (d) the same as (c) but after 2 hours.

diation with photons of energy lower than 0.73 eV (see Fig. 2). In the range from 12 to 35 K this effect was temperature independent. On SI sample for this energy of photons no effect was detected even after prolonged illumination.

TABLE

Exper. techn.	Temperat. (K)	Excitation source	Recov. peak (eV)	EL2 recov. (%)	Ref.
PL	4.2	Ar laser (2.41 eV)	—	< 80	[1]
PL	4.2	YAG laser (0.94 and 1.17 eV)	—	100	[2]
PTD	77	monochrom. (hal. lamp)	0.80	< 1	[3–5]
PTC	77	hal. lamp ?	0.855	< 12	[6]
IR	77	monochrom. (hal. lamp)	0.90	< 15	[7]
IR	9 to 77	monochrom. (hal. lamp)	1.4 (many peaks)	up to 100	[8]
IR	11	YAG laser (0.94 eV)	—	< 27	[9]
EPR	90 to 110	monochrom. (hal. lamp)	0.8	10 to 50	[13]

PL indicates photoluminescence, PTD - photocondutivity, PTC - photocapacitance
IR - infrared absorption, EPR - electron paramagnetic resonance

The fact that at low temperature the rate of recovery under illumination with 1.45 eV photons is similar for samples with strongly different free electron concentration seems to exclude the explanation of the effect as being due merely to photogeneration of free electrons. On the other hand a range of energies of photons causing the effect is sample dependent therefore it is also unlikely that the recovery is caused by a direct absorption of photon by the defect in its metastable configuration. Thus it remains the third possibility that the effect is caused by a change of a charge state of the metastable configuration due to trapping of the photoexcited electron. Such explanation is in agreement with recent findings of Baj et al. [13] who showed that EL2 in the metastable configuration is an electron trap.

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