Study of degradation and regeneration of silicon polymers using cathodoluminescence

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Silicon polymers are widely studied materials in recent years, because they show very promising properties for the application in electronics. Their properties such as phase of matter, thermochromism, piezochromism, semiconductivity, photoreactivity, light emission and optical nonlinearity, have become very interesting. Our interest has been focused on the group of polysilanes (often also called polysilylenes), especially on poly[methyl(phenyl)silylene] (PMPhSi), having linear backbone of linked silicon atoms. Cathodoluminescence (CL) degradation and regeneration of PMPhSi are presented in this paper.

The studied PMPhSi was prepared by the Wurtz coupling polymerization [1]. The low-molecular weight fractions were extracted with boiling diethyl ether. The layers for the CL measurements were prepared from a toluene solution by casting on quartz disk substrates. For electron beam experiments the PMPhSi specimens were covered with Al sputtered film of 50 nm. A modular CL equipment [2] build in our laboratory was used for the study of PMPhSi. A specimen of PMPhSi was positioned at the face of a light guide, and the CL emission was collected from the substrate side of the specimen. At the CL spectra measurement, the emitted light was guided to the entrance slit of the monochromator, and the PMT was positioned at the exit slit of the monochromator. The equipment was controlled by a PC using the IEEE-488 bus.

Spectrally resolved CL intensities of PMPhSi are shown in Fig. 1 and Fig. 2. The typical spectrum of PMPhSi is characterised by the dominating narrow UV band (357 nm) and by a weak broad visible band (420-570 nm). The spectra in Fig. 1 were recorded using continual uniform electron beam irradiation. The measurement was started with a non-irradiated specimen, and CL spectrum recording was repeated in intervals as written in the figure labels. It can be seen that the UV emission decreases rapidly, whereas the visible one is almost unchanged during electron beam irradiation. The spectra in Fig. 2 were recorded during regeneration of the degraded specimen kept in vacuum at the room temperature. It can be seen that UV emission is being partially restored during regeneration. The decrease of the UV emission is either a consequence

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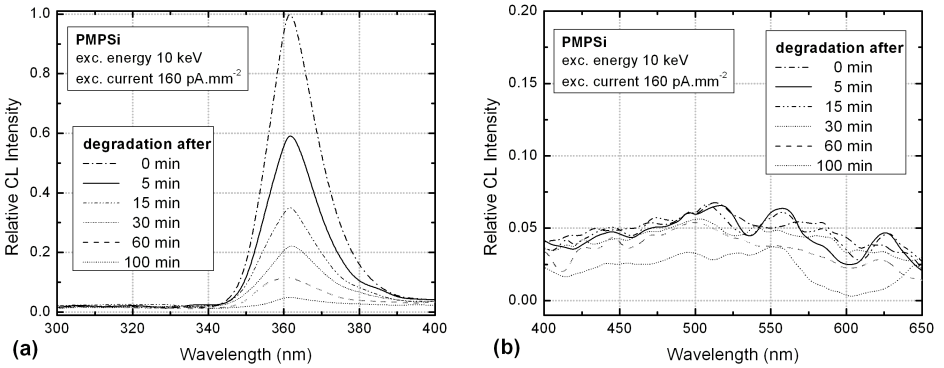

Figure 1. Spectrally resolved CL intensities of PMPhSi during degradation by the electron beam of 10 keV, 160 pA.mm^{-2}. (a) Characteristic UV emission, (b) broad visible emission.

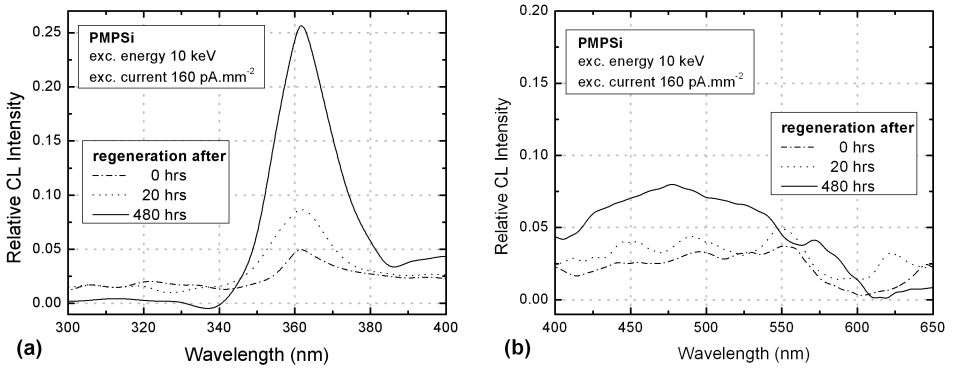

Figure 2. Spectrally resolved CL intensities of PMPhSi during regeneration in vacuum at the room temperature. (a) Characteristic UV emission, (b) broad visible emission.

of Si-Si bond scission or of Si-Si bond deformation and deviation from the optimally bonded structure [3]. The Si-Si bond scission, crosslinking or weak bond formation are all possible mechanisms, depending on the excitation conditions. A recovery of CL spectra during regeneration indicates a self-healing effect, resulting in reversibility of changes observed. We kindly acknowledge the support of the project [4].

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