Studies on the Reversibility of Voltage-Tunable Luminescence of Porous Silicon

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The observation of remarkable luminescence of porous silicon (PS) at room temperature in 1990 spurred scientific interest in the world scale for its potential significant applications in flat panel display technology and possibly in optoelectronics(1-3). It is shown that both the PL (photoluminescence) and EL (electroluminescence) could be explained by the quantum confinement effect, and the surface properties greatly affects its EL (4-6). We have successfully carried out the voltage tunable emitting of PS in solutions, which brought hope to making Si-based optoelectronics devices. In the present work , the reversibility of EL of PS in solutions is studied.

EXPERIMENTAL

PS was obtained from anodization of phosphorus – doped n-type silicon wafers of (100) orientation, the resistivity of 1.5×10^{-2} Ω cm for anodic biases, and 3~5 Ω cm for cathodic biases. The electrolyte for anodization is HF16wt% in ethanol. The Si samples were etched galvanostatically at a current density of 5 mA cm^{-2} for 10 minutes under illumination of halogen- tungsten lamp. After formation the PS sample were rinsed with ethanol and immersed in 1.0 $mol.dm^{-3}$ formic acid-sodium form-ate for anodic biased test or in 0.20mol.dm^{-3} $(NH_4)_2S_2O_8$-0.5 mol.dm^{-3} $N_{a2}SO_4$ for cathodic biased test. PE LS 50B luminescence spectrometer coupled with HD HA301 potentiostat galvanostat were used for monitoring EL. The tapping mode atomic force microscope was carried out on nanoscope IIIa made of Digital Instruments. Two-electrode system was employed. Large area of platinum foil was used as the assistant electrode. All the tests were made under room temperature.

RESULTS AND DISCUSSION

Fig.1 shows the spectra of PS in 1.0 mol.dm^{-3} formic acid-sodium formate under positively biases. It was shown that the blueshift of EL occurred when the anodic polarization was increased.

Studies showed that the intensity and energy of EL depended upon the modes in which the bias was exerted. Either the intensity or the wave energy for the EL of PS is higher when certain potential is directly exerted than seriately changed to the same potential,as shown in Table 1. The similar phenomenon was also discovered in the case of EL of PS under cathodic biases, as seen in Fig.2, which proved that there must be some correlation between the two type of EL(6). When the biases were exerted from high to low, in the same bias range as in Fig.1, the irreversible phenomenon of EL was discovered. However, in the lower and narrow biases range, the EL could also be observed, but the wavelength became red shift compared with that when the biases were exerted from low to high, as seen in Fig.2. The EL of PS in solutions can be explained with quantum confinement effect.

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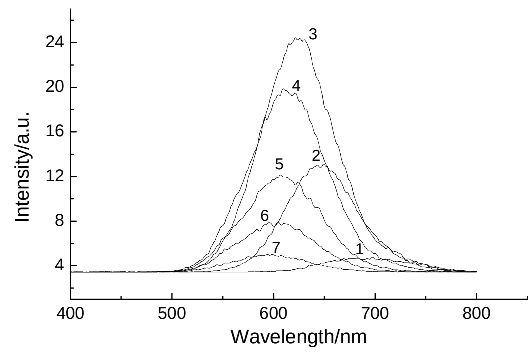

Fig.1 EL spectra obtained at different positive biases
Solution: 1.0 mol.dm^{-3} NaOOCH/HCOOH
(1)1.70V,(2)1.73V,(3)1.80V,(4)1.86V,(5)1.88V,(6)1.92V,(7)1.94V

Table 1. Comparison of parameters of EL of PS at certain positive biases exerted in different modes

Bias mode	Voltage /V	Intensity /a.u	Wavelengh /nm
Given	1.6	27	570
Seriate	1.7	4.8	670
Given	2.1	44	541
Seriate	2.1	4.0	590

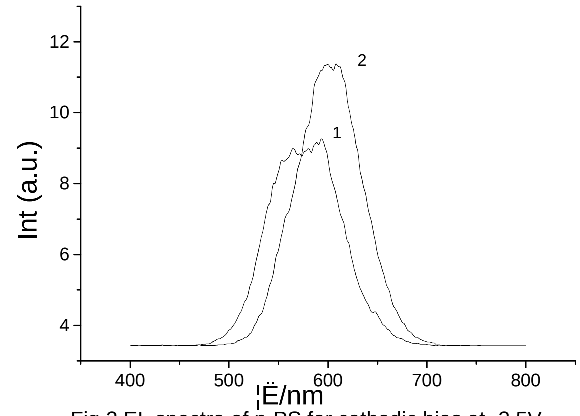

Fig.2 EL spectra of n-PS for cathodic bias at -3.5V
1. 1st EL 2. 2nd EL in 0.20mol.dm^{-3} $(NH_4)_2S_2O_8$ - 0.5 mol.dm^{-3} Na_2SO_4