

The low-temperature photoluminescence of thin Si-C-N films

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Nowadays, silicon carbon nitride (Si-C-N) is one of the promising multi-functional materials. Numerous studies introduce thin Si-C-N films as possible components for use in optoelectronics and protective wear-resistant applications. The reason for it is that the physical and chemical properties of Si-C-N could be easily customized in a wide range by preparation techniques and materials composition. Our previous works demonstrate a strong dependence of the intensity and shape of the photoluminescence (PL) spectra of Si-C-N films on the hydrogen content. However, the temperature-dependent PL spectra of Si-C-N films have not been studied yet. This work continues the investigation of the PL spectra of Si-C-N films. In particular, the low-temperature PL spectra (77 K) were studied for the first time.

Fig. 1 shows IR spectra. There is one broad absorption band in the range of 650-1250 cm^{-1} and several small bands. To investigate the broad band in detail we decompose it by Gaussian components (Fig. 2).

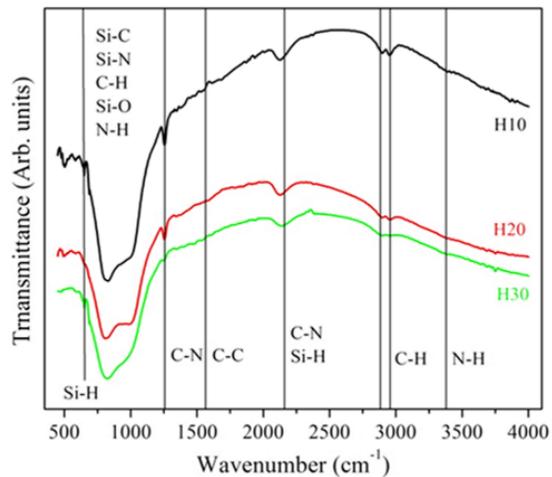


Fig. 1. Film thickness normalized FTIR spectra of the deposited films.

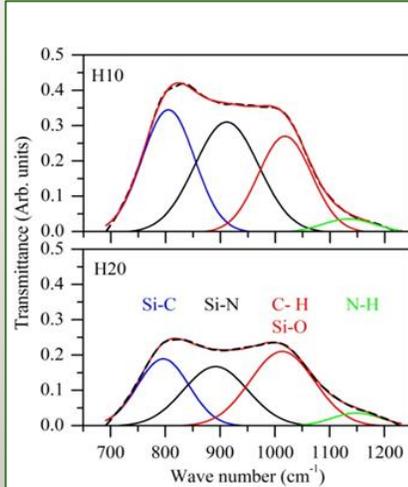


Fig. 2. Experimental FTIR spectra and their deconvoluted counterparts. The inversion of the bands was done: the higher the peak, the higher the absorption and the lower the transmittance is.

The broad band is related to the vibrations of the Si-C, Si-N, C-H (Si-O) and N-H bonds. An addition of hydrogen to gas mixture in the reaction chamber leads to a weakness of the Si-C and Si-N vibrations compared to the C-H/Si-O ones. An increase of hydrogen flow rate does not result to a noticeable increase of the hydrogen bands in other region of the spectra. This prompts us to suppose that the saturation of the films by hydrogen occurs at minimum F_H .

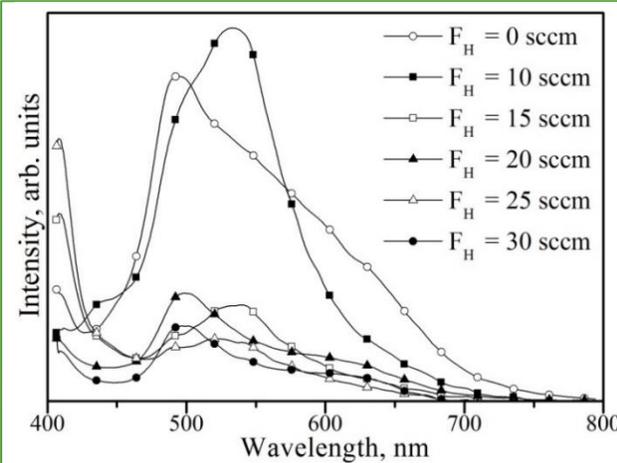


Fig. 3. PL spectra of a-SiCN:H deposited with different hydrogen flow rates (F_H).

The relative intensity of the band related to the Si-H bonds increases with F_H indicating that the passivation of silicon dangling bonds increases. The intensity of PL (fig. 3) increases with decreasing amount of added hydrogen and reaches the maximum value when the hydrogen is absent in the reaction mixture. **It follows that the silicon dangling bonds is responsive for the observed bright PL (cf. Fig. 1).** We suppose that in the films saturated by hydrogen most silicon dangling bonds are passivated. A number of the defective silicon cluster is low. As a result, the PL such films will be quenched. The peak of PL falls on 500-550 nm that corresponds to 2.3-2.5 eV. This indicates that the defect states could be localized at the band tails of the SiC network.

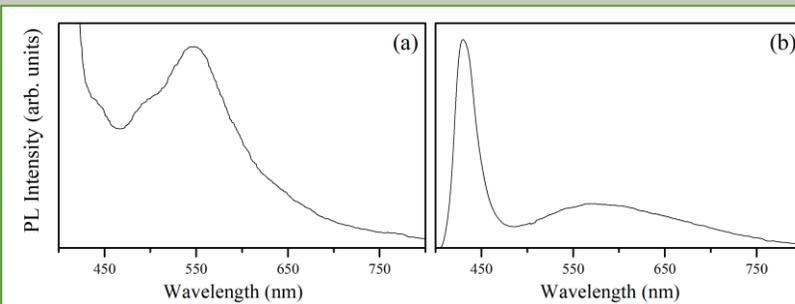


Fig. 4. PL spectra of Si-C-N films deposited at $F_H = 15$ sccm measured at room temperatures (a) and 77 K (b). Spectra were excited with 395 nm line.

PL spectra measured at room temperature were characterized by a broad PL band in the visible region Fig.4. Cooling of the samples resulted in sufficient increasing and narrowing the high-energy part of the spectrum Fig.4(b). Such changes of the PL spectrum suppose the existence of the nanocrystalline particles within the amorphous network as well as the possible formation of several phases with different contributions to the PL.

Further structural analysis for a deeper understanding of the PL spectra is ongoing.