11th International Conference on Advanced Materials
ICAM 2009
Rio de Janeiro Brazil
September 20 - 25

Photoluminescence from Ge nanocrystals produced by hot implantation into SiO_2

F.L. Bregolin [(1)], S. Reboh [(1)], U.S. Sias [(2)], M. Behar [(1)] *, E.C. Moreira[(3)]

(1) Instituto de Física - Universidade Federal do Rio Grande do Sul C.P. 15051, 91501-970, Porto Alegre, RS, Brazil.
(2) Instituto Federal de Educação, Ciência e Tecnologia Sul-rio-grandense – Campus Pelotas, 96015-370, Pelotas, RS, Brazil.
(3) Universidade Federal do Pampa – Campus Bagé, 96400-970, Bagé, RS, Brazil.
* Corresponding author.

Abstract – By using the ion implantation technique, photoluminescence (PL) from Ge nanocrystals (Ge NCs) has been obtained by room temperature (RT) Ge implantation into a SiO_2 matrix followed by a high temperature anneal. In the present work we have used another experimental approach: We have performed the Ge implantation at high temperature and then a high temperature anneal at 900 ℃. By performing the implantation at 350 ℃, a PL yield three times larger than the one obtained from the usual RT implantation at the same fluence was produced. As revealed by transmission electron microscopy (TEM) observations, this result is a consequence of the different mean size distributions of the Ge NCs as obtained by hot and RT implantations.

Since the discovery of photoluminescence (PL) in porous Si [1] a large number of studies, concerning the properties of Si or Ge nanoclusters (NCs), have been reported. Several techniques have been used in order to produce the NCs embedded in the matrix: sputtering [2], chemical vapor deposition (CVD) [3], and in particular, the ion implantation technique [4-6]. However, in all the cases regarding ion implantation, the Ge implantation was performed at room temperature (RT), followed by a high temperature annealing.

Instead of performing Ge implantation into the SiO_2 layer at RT, in this paper report a novel approach: By keeping the substrate at higher temperatures during implantation, followed by annealing at 900 ℃ in order to produce the Ge NCs. This was mot ivated by previous results for other systems, where a quite large PL yield was obtained by using the hot implantation technique [7, 8].

By comparing the present results to the ones reported in previous works where the implantation was performed at RT [9], we have obtained a significant increase in the PL yield (almost a factor three) by performing the Ge implantation at 350℃ and further anneal at 900℃ – see Fig. 1. The main reason for this behavior was revealed by TEM analyses, which have shown that hot implants induce the formation of mostly smaller Ge NCs, and also a higher number of them, despite having a broader size distribution, as compared to the ones obtained by RT implantation – see Fig. 2. Therefore, since the origin of the PL is due to radiative interface defects, more Ge atoms are involved in the PL emission. However, we do not discard other mechanisms that can contribute to the increase of the PL yield.

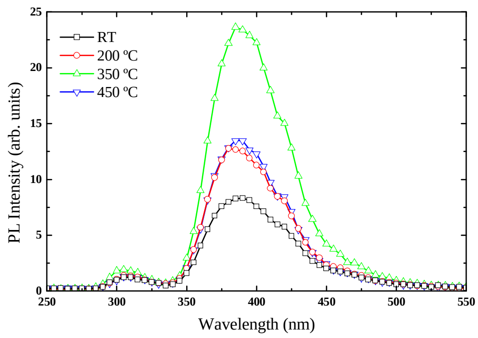

Figure 1: PL spectra from samples implanted at different temperatures.

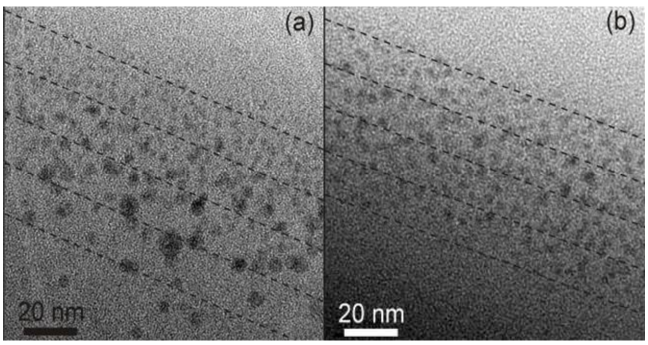

Figure 2: TEM image showing the profile of the sample and the Ge NCs distribution in the SiO2 matrix by **a)** hot implantation at 350 ºC and **b)** RT implantation.

[1] T. Canham, Appl. Phys. Lett. 57, 1046 (1990).
[2] Q. Zhang, S. C. Bayliss, and D. A. Hutt, Appl. Phys. Lett. 66, 1977 (1995).
[3] H. Takagi, H. Ogawa, Y. Yamazaki, et al., Appl. Phys. Lett. 56, 2379 (1990).
[4] T. Shimizu-Iwayama, K. Fujita, S. Nakao, K. Saitoh, T. Fujita, and N. Itoh, J. Appl. Phys. 75, 7779 (1994).
[5] L. Rebohle, J. von Borany, H. Fröb and W. Skorupa, I. E. Tyschenco, H. Frosand and K. Leo, Appl. Phys. Lett. 71, 2809 (1997).
[6] K. V. Shcheglov, C. M. Yang, K. J. Vahala, and Harry A. Atwater, Appl. Phys. Lett. 66, 745 (1995).
[7] U. S. Sias, M. Behar, H. Boudinov and E. C. Moreira, J. App. Phys. 102, 43513 (2007) and references there in.
[8] F.L. Bregolin, M. Behar, U.S. Sias, E.C. Moreira, Nucl. Instrum. and Meth. B, 267, 1314 (2009).
[9] J. M. J. Lopez, F. C. Zawislak, M. Behar, P. F. P. Fichtner, L. Rebohle, W. Skorupa, J. Appl. Phys. 94, 6059, (2003) and references there in.