Light emission from silicon with tin-containing nanocrystals

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Photonics is the technology of generating and harnessing light. Emissions, transmission, modulation, signal processing, and detection/sensing of light are the main areas of research. Photonics has a wide range of potential applications in areas ranging from everyday life to the most advanced science, e.g. light detection, telecommunication, server data transfer, and photonic computing (Figure 1).

In order to achieve efficient light emission, one strategy is to continue the work obtained with silicon (Si) in the computer industry; however, the combination of electrical and optical functionality in silicon is hindered by the indirect band gap. A promising means of overcoming this limitation is to add different combinations of group-IV elements. In this work one such strategy is investigated: embedding nanocrystals containing tin (Sn) inside crystalline silicon.

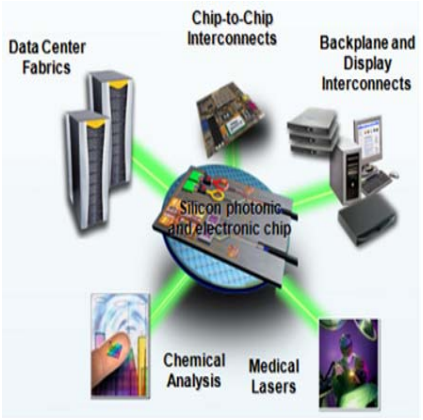

Figure 1: Silicon photonics has a wide application prospect. Here a few of the applications has been shown. Photocredit: Intel

Tin comes in two forms, α-Sn and ß-Sn, which are respectively a direct-band-gap semiconductor and a metallic material. For bulk Sn the transitions occurs at 13.2°C, with ß-Sn being the stable form above this temperature. The aim is to utilize the semiconducting nature of α-Sn, for which the direct optical transition is predicted to remain strong in nanocrystal regime [1]. Furthermore, combined with size control of the nanocrystals tuning of the emission energy should be possible.

In our study [2], the Sn-containing nanocrystal samples were grown using molecular beam epitaxy on a Si(100) wafer, with a wafer resistivity of 75-125 Ω cm. A 100 nm thick Si buffer layer was grown to ensure a high quality defect free surface. Following the buffer layer a 30 nm composite layer of Si, Sn, and C was grown. The co-deposition was done at 200°C with a growth rate of 0.3 Å/s. Post growth annealing was carried out in an N2 atmosphere at temperatures varying from 650°C to 900°C for 20 min. in order to form the nanocrystals.

We present the dependence of the observed luminescence on the temperature of the heat treatment, and we correlate our observations with the structural characterization techniques, transmission electron microscopy and Rutherford backscattering spectrometry.

1. R. V. S. Jensen, et al., Phys. Status Solidi (c). 8, 1002 (2011).
2. S. Roesgaard, et al., A IP Adv., 5(7):077114 (2015).