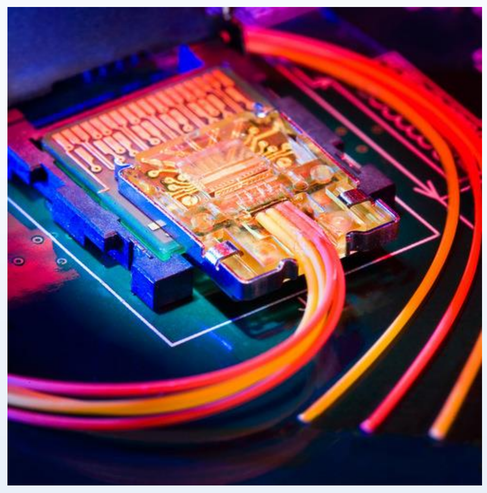
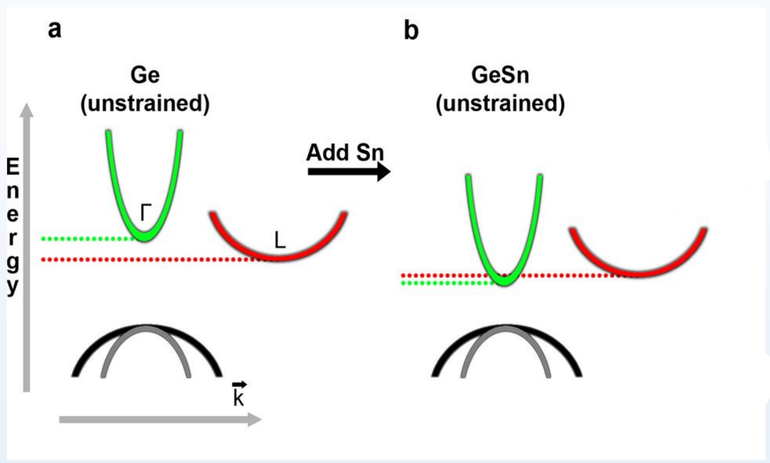
Photoluminescence Properties of GeSn Film with High Sn Contents on Ge (001) Substrate by Molecular Beam Epitaxy

T. Liu, L. M. Wang, G. J. Zhu, X. F. Hu, Z. Y. Zhong, X. J. Yang, Z. M. Jiang*
State Key Laboratory of Surface Physics, Fudan University, Shanghai 200433, China

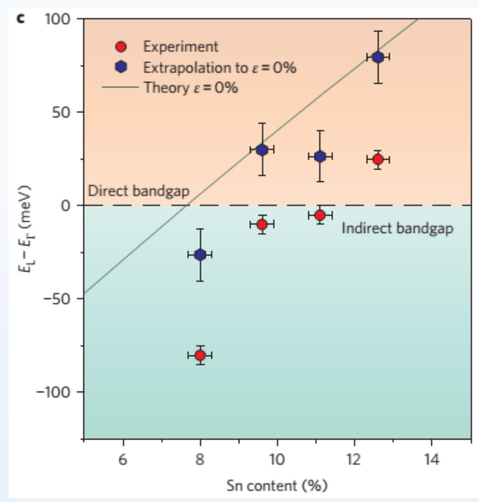
Introduction

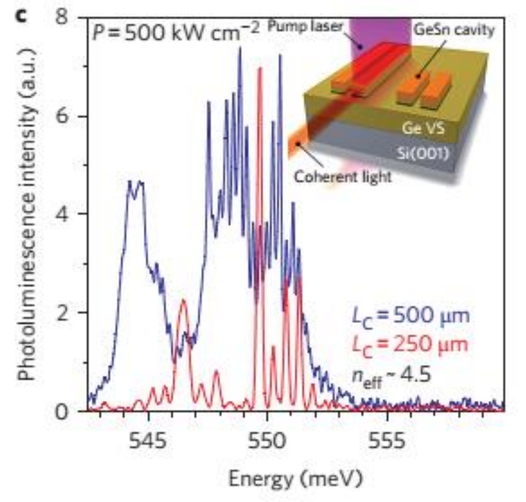


- Si-based optical interconnection technology is considered to be most promising technology due to advanced Si IC technology.



- A schematic of Sn alloying on the band structure of Ge. Adding substitutional Sn to the Ge lattice lowers the Γ- and L-valleys in energy, with Γ lowering faster than L.





- In recent years, lots of efforts have been made in the epitaxial growth of high-quality GeSn crystals to achieve direct bandgap light emitting.
  - R. Chen et al., Nano Letters, 14 (1), 37-43 (2014).
  - S. Wirths et al., Nature Photonics, 9 (2), 88-92 (2015).

Growth and photoluminescence properties of GeSn film

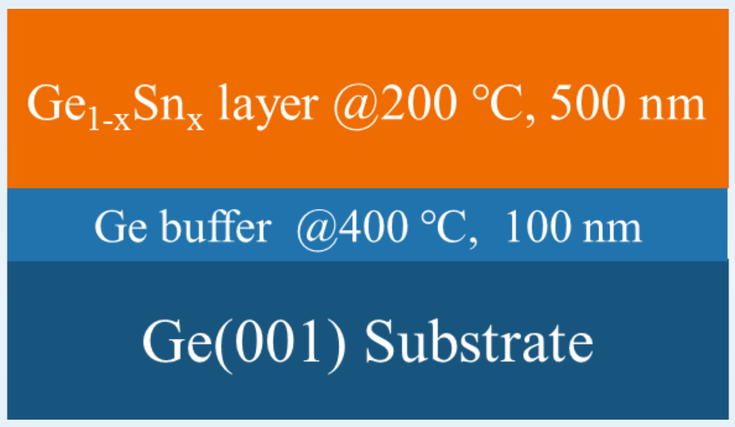


Fig. 1 Structure schematic of samples.

- A series of samples (samples A, B, C and D with Sn contents of 3 %, 6 %, 9 % and 11 %) were grown on Ge (001) substrate by molecular beam epitaxy.

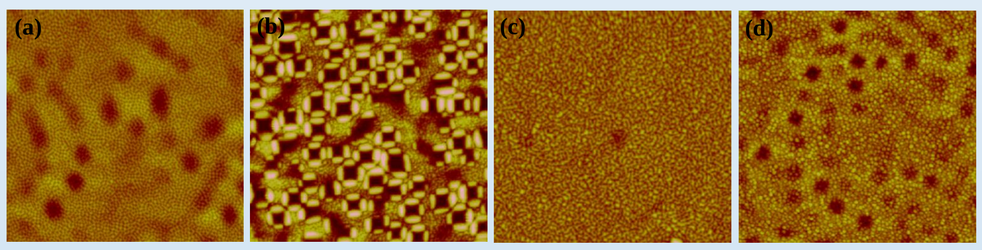


Fig. 2 AFM images of (a) sample A, (b) sample B, (c) sample C and (d) sample D.

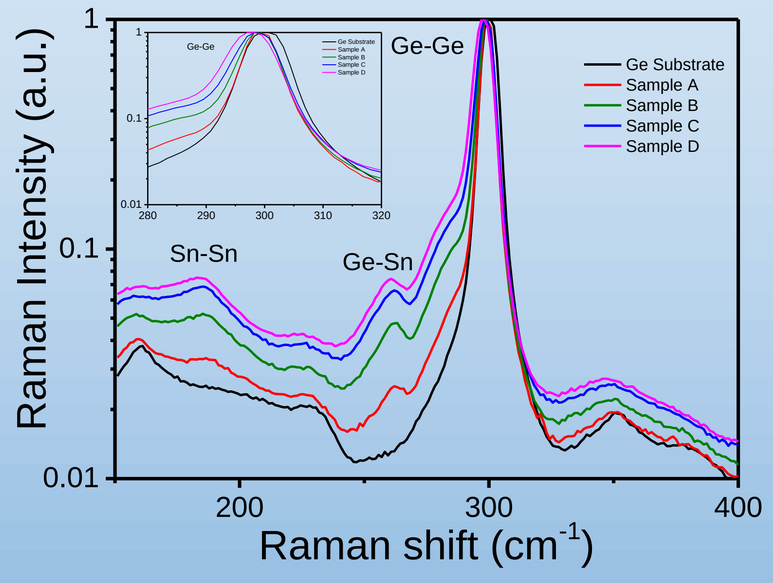


Fig. 3 Raman spectra of the series samples.

- The Ge peak position at around 300 cm^{-1}, while the GeSn peak position was identified around 260 cm^{-1}. The Ge-Ge peak position moved to smaller wavenumbers and the intensity ratio of Ge-Sn peak and Ge-Ge peak increased with the Sn contents increased in the samples, which indicated that more Sn atoms substituted the Ge atoms sites in lattice.

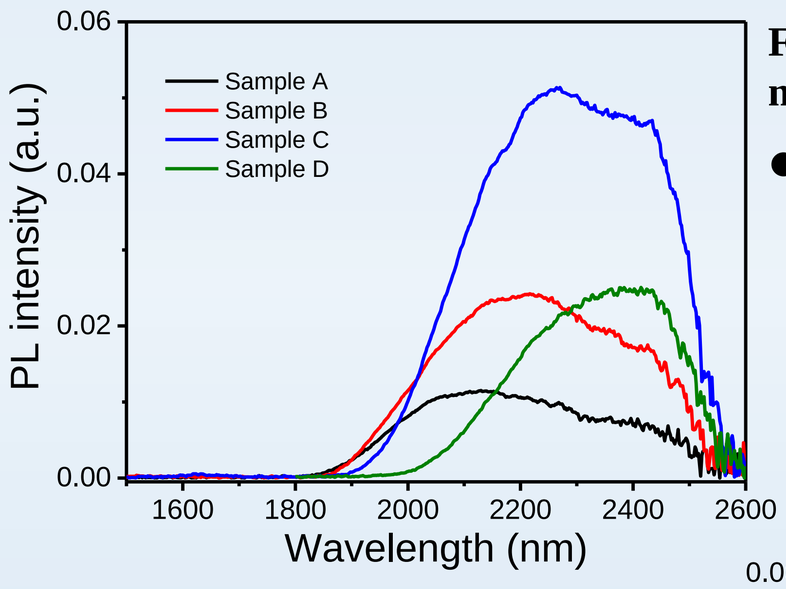


Fig. 4 PL spectra of the series samples measured at 20 K.

- Red-shifted PL peaks were ascribed to the higher Sn contents and smaller bandgaps, accordingly. The PL peak position of Sample D with 11 % Sn content was near to 2400 nm, which may indicates a direct bandgap achieved in sample D.

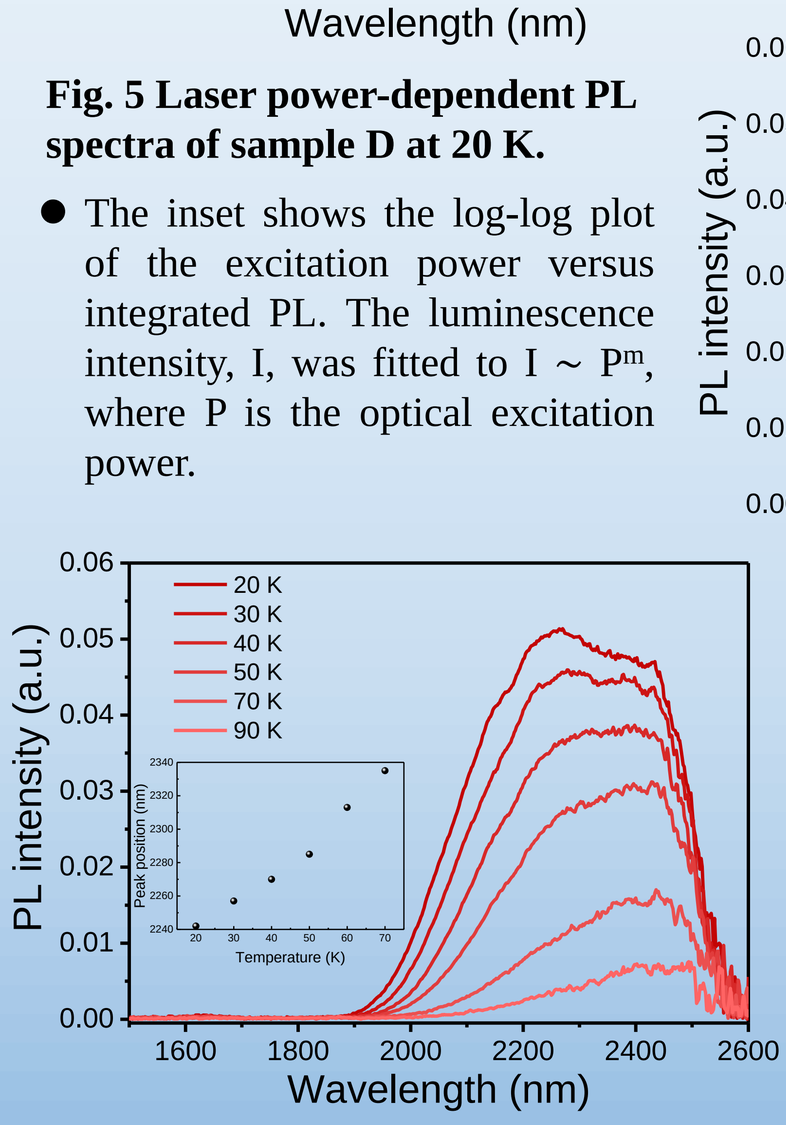


Fig. 5 Laser power-dependent PL spectra of sample D at 20 K.

- The inset shows the log-log plot of the excitation power versus integrated PL. The luminescence intensity, I, was fitted to $I \sim P^m$, where P is the optical excitation power.

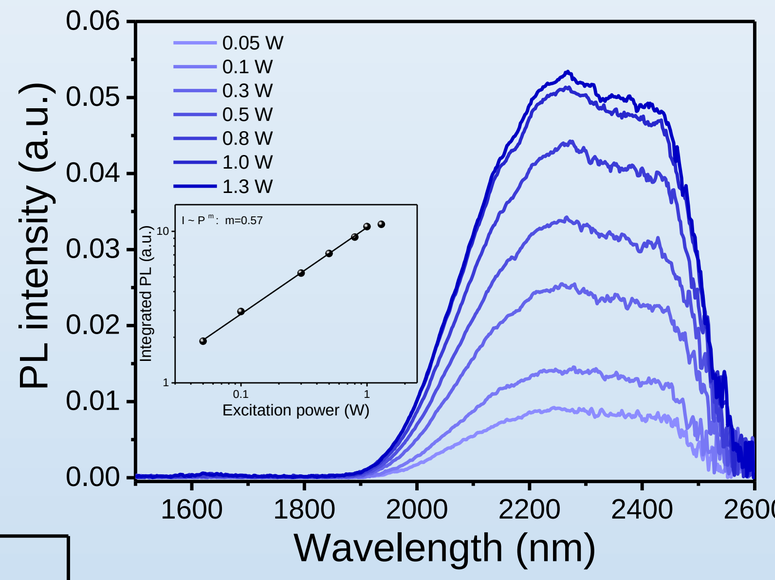


Fig. 6 Temperature-dependent PL spectra of Sample D. The inset shows the redshifts of the peak position with the temperature increase.

Conclusions

- **GeSn film samples with Sn contents of 3,6,9 and 11 % were grown on Ge (001).**
- **The PL peak shifts towards longer wavelength, indicating the reduced bandgap energy due to the incorporation of Sn.**
- **The peak positon of sample D extended to 2400 nm at 20 K. A direct band-gap may be achieved in sample D.**