Growth of $Ge_{1-x}Sn_x$ heteroepitaxial layers with high Sn content on InAs (001) substrate

<u>N M. Eldose</u>,[1] H. Stanchu,[2] C. Gunder,[1] C. Li, [1] F. M. de Oliveira,[1] Yu. I. Mazur[1], M. Bernama,[1] S.-Q. Yu[2], and G. J. Salamo[1]

[1] *Institute of Nanoscience and Engineering, University of Arkansas, Fayetteville, AR 72701, USA*

[2] *Department of Electrical Engineering, University of Arkansas, Fayetteville, AR 72701*

Group IV alloys of Ge and Sn ($Ge_{1-x}Sn_x$) are extensively studied for various electronic and optoelectronic applications on a Si platform. Alloying GeSn with α-Sn concentrations as low as 6% [1] allows for an indirect to direct optical transition compared to Ge. Higher Sn content makes possible mid and even long-range infrared optical emission and detection [2,3]. At the same time, due to the low solid solubility of Sn in Ge (~1%) as well as the large lattice mismatch of α-Sn with Ge (~14%), the realization of Sn-rich $Ge_{1-x}Sn_x$ structures is challenging.

We will discuss the growth and investigation of crystalline $Ge_{1-x}Sn_x$ heteroepitaxial layers with Sn percentage higher than 14% on InAs (001) substrates. Utilizing the small lattice mismatch between $Ge_{1-x}Sn_x$ layers and the InAs (001) substrate, we achieved epitaxial growth of $Ge_{1-x}Sn_x$ with a high Sn percentage (>30%) by applying a high Sn gradient during growth. The strain induced in the GeSn layers was investigated and the effect of gradually increasing the Sn content of the GeSn lattice significantly affected the composition and morphology of the GeSn layers. Supporting data (Figs 1-3) on the structural properties of $Ge_{1-x}Sn_x$ alloys using X-ray diffraction, SIMS analysis, XTEM and Raman spectra will be discussed and are shown below.

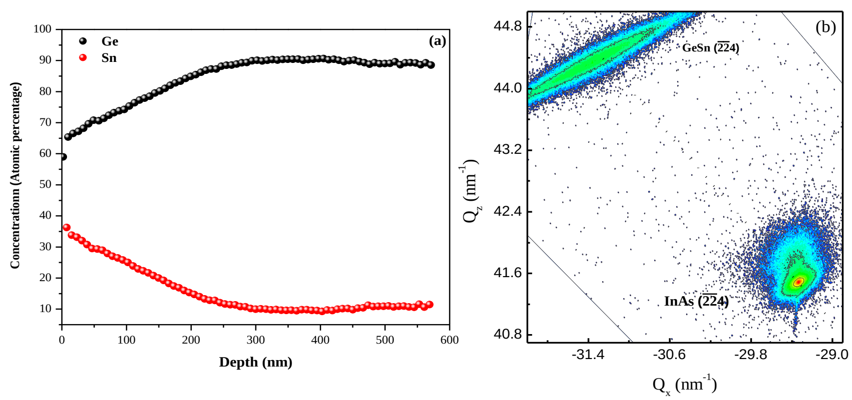

Fig. 1. SIMS profile (a) and RSM analysis of (b) $Ge_{1-x}Sn_x$/InAs (001)

[1] S. Wirths, D. Buca, S. Mantl, Prog. Cryst. Growth Charact. Mater. 2016, 62 (1), 1−39.
[2] W. Dou, M. Benamara, A. Mosleh, J. Margetis, P. Grant, Y. Zhou, S. Al-Kabi, W. Du, J. Tolle, B. Li, M. Mortazavi, S.- Q. Yu, Sci. Rep. 2018, 8 (5640), 1−11.
[3] J. Bass, H. Tran, W. Du, R. Soref, S.-Q. Yu, Opt. Exp. 2021, 29 (19),30844-30856.

+ Author for correspondence: nmeckama@uark.edu

Supplementary Information:

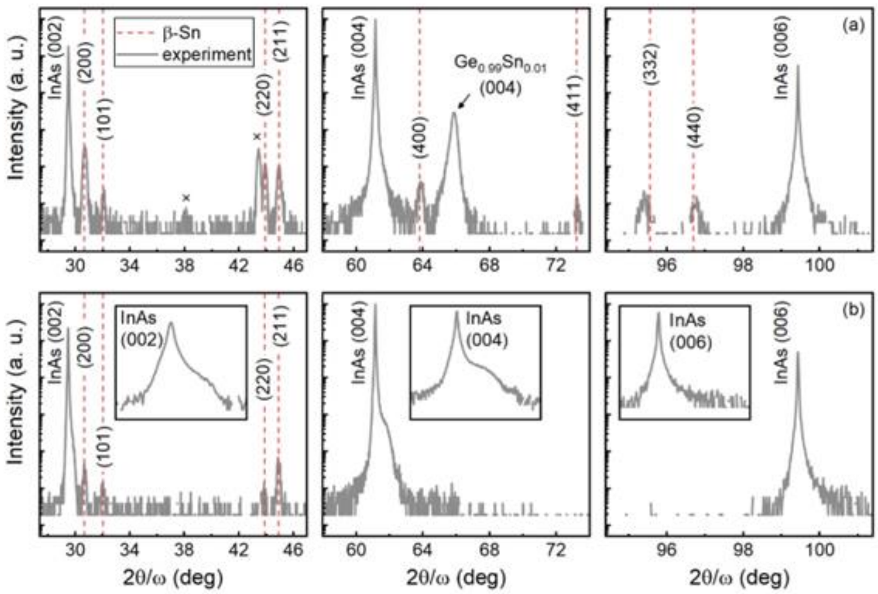

Figure 2. Symmetrical X-ray diffraction 2θ/ω scans showing the formation of GeSn and β-Sn phases on InAs (001) substrate

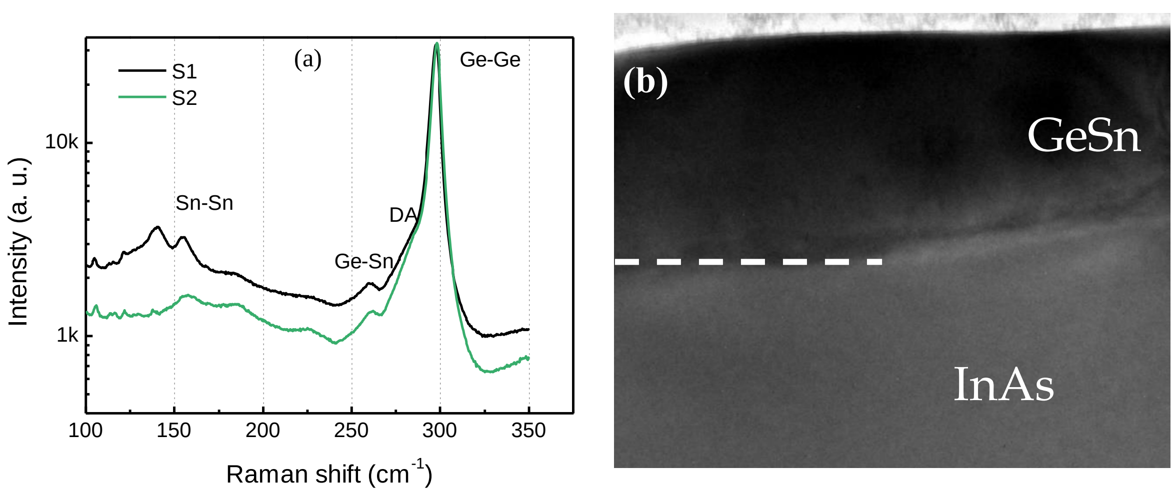

Fig. 3. (a) Raman spectra of two distinct regions and (b) XTEM image of $Ge_{1-x}Sn_x$/InAs (001)