BIO Web of Conferences **129**, 24030 (2024) https://doi.org/10.1051/bioconf/202412924030
EMC 2024

Strain mapping and simulation of transistor structures in a 22nm FDSOI technology

Dirk Utess[1], Dominik Martin Kleimaier[1], Etienne Billan[1], Tashfain Youssuf[1], Zhixing Zhao[1], Thorgund Nemec[1], Dr. Moritz Andreas Meyer[1], Dr. Jochen Rinderknecht[1]
[1]GlobalFoundries, Dresden, Germany

Background & aims

With the advent of the AI/ML and 5G/Satellite internet era, modern electronic devices need to be operated with low energy consumption, high performance, radiation hardness and manufactured at low cost. One of the technologies is 22FDX offered by GlobalFoundries® which utilizes a fully depleted silicon-on-insulator (FDSOI) technique. Speed and power consumption of devices are improved accordingly. Introducing mechanical strain to transistor channels e.g. by epitaxial growth or process-induced pre-stressed overlayers or periphery layouts alters the crystal lattice and thus also the band structure of the semiconducting channel. As different requirements of strain for N- or P-type transistors e.g., along the direction of the channel, the characterization of strain in electronic devices is necessary, both for monitoring the intended engineered strain but also the unintended strain states. However, for verification as well as enhancing strain, FEM Simulation of Strain is crucial. The second part of this study focuses on the simulation of transistors. A detailed model is developed that includes mechanical and structural parameters. [1, 3]

Methods

Precession Electron Diffraction (PED) is a specialized technique in Transmission Electron Microscopy (TEM) employed to gather electron diffraction patterns while scanning across the designated region of interest. During the scanning process, the electron beam rotates around the central axis, while the beam itself is tilted at a specific angle. This results in a quasi-kinematical diffraction pattern, which facilitates the use of a more sophisticated algorithm for crystal structure determination. The strain simulation, based on the finite element method, started with a basic structural model and mechanical parameters. After validating this fundamental model with corresponding structures at the transistor size level, increasingly complex models were developed and subsequently verified. [2, 4]

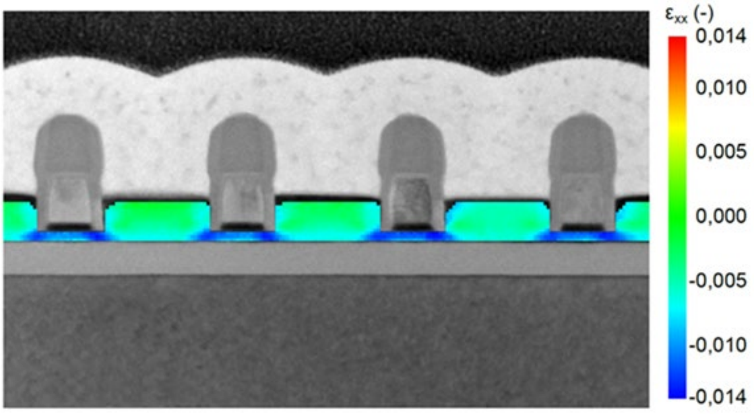
Results

In this study, strain maps and graphs will be presented obtained from both experimental data using PED and simulated data from various transistor devices. These strain maps exhibit excellent agreement with each other as well as with electrical measurements. Furthermore, they enable the verification and identification of new stress elements, highlighting potential areas for improvement by adjusting structural dimensions and addressing distinct stress elements.

Conclusion

This holistic approach—combining simulation and measurement—enables a comprehensive understanding and optimization of strain effects in electronic components. It also promotes the progression of 22FDSOI technologies and beyond. Finally highlighting the Significance of Advanced TEM Techniques in the Semiconductor industry.

Graphic:



Keywords:

Strain, FDSOI, Transistor, Simulation, PED

Reference:

[1] D. Kleimaier, Z. Zhao, D. Utess, I. Saadat, F. Ravaux, K. Sloyan (2019). Strain mapping of transistor structures in a 22nm Fully Depleted Silicon-On-Insulator technology. CARAC 2019 - Advanced Material Characterization Workshop, Grenoble
[2] T. Yousuf: Impact of Strain Produced by Diverse Structures and Si1-xCx as Source/Drain Material on Electron Mobility in FDSOI Transistors using COMSOL Simulations and TEM Analysis of Real Models, Masterarbeit, TU Dresden, 2020
[3] J. Hoentschel, L. Pirro, R. Carter, M. Horstmann: 22FDX® Technologies for Ultra-Low Power IoT, RF and mmWave Applications. ISTE Science Publishing, London, 2019.
[4] NanoMEGAS SPRL: Precession Electron Diffraction Applications. Online resource. https://nanomegas.com/precession-electron-diffractionand-applications/
[5] R. Thomas, D. Benoit, L. Clement, P. Morin, D. Cooper. F. Bertin: Characterization of stress transmission from silicon nitride layer to transistor channel. Journal of Physics: Conference Series 326 (2011) 012058