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APPLICATIONS

Silicon Germanium ($Si_{1-x}Ge_x$)

With the development of the microelectronics, the epitaxial structures of semiconductors become more and more complex. $SiGe_x$ system is widely studied for high speed heterojunction transistors (HBT). Indeed the insertion of $SiGe_x$ in bipolar transistor produces higher cut-off and maximal frequencies (around 100 GHz) and simultaneously reduces the noise and power dissipation.These devices, when incorporated into RF or microwave components, make $SiGe_x$ a strong competitor to GaAs.

The need of precise characterisation technique capable to determine at the same time the thickness and the composition of such samples is obvious.

Spectroscopic Ellipsometry(*), which is **contactless, non destructive and allows on-line control**, is an excellent technique to perform such characterisation.

Figure 1 shows several $SiGe_x$ refractive indices with different Germanium contents determined with one of the **SOPRA Ellipsometers**. The optical properties of these materials depends on the composition; as shown in figure 1, the position of the optical band gap E1 shifts with the Ge content x.

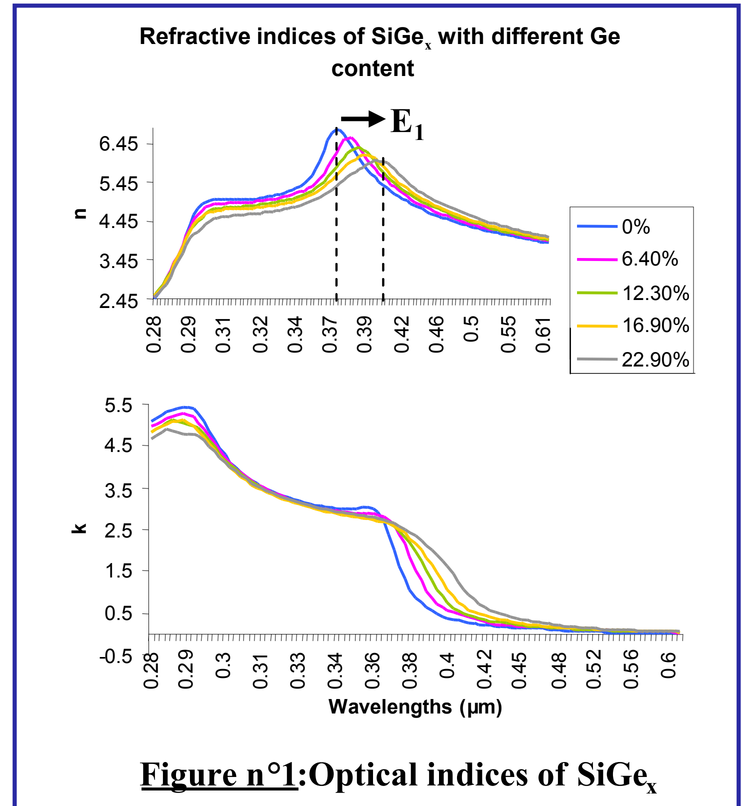

Figure n°1:Optical indices of $SiGe_x$

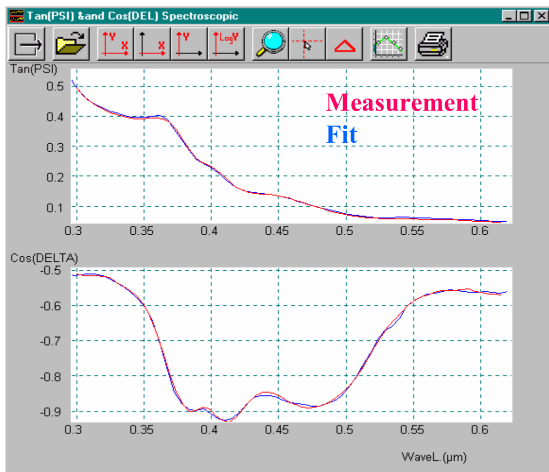

Figure n°2-a : SiGe measurement

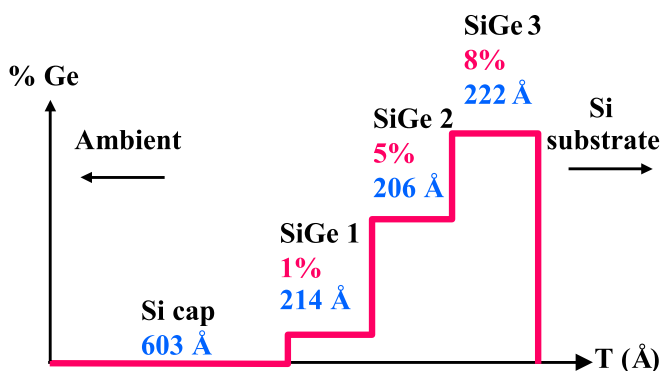

Figure n°2-b : Typical $SiGe_x$ graded structure with cap

Figure 2-a shows the measurement, taken in scanning mode, of typical $SiGe_x$ structure (Si cap / $SiGe_x$ graded / Si).

After running SOPRA's regression the best fit and the experimental curves are presented. The excellent agreement between the measurement and the model is to be seen.

Figure 2-b presents the structure of the sample and the results obtained.

From the measurement of two parameters (TanΨ and CosΔ), **Spectroscopic Ellipsometry(*)** can easily determine **at the same time and independently the thicknesses of each layer** within the stack as well as **the Ge content** of the three $SiGe_x$ layers and so, to **characterise the shape of the graded layer**.

(*)Refer to SOPRA web page (www. SOPRA-SA.com) for tutorial on ellipsometry principles, terminology and products.

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SOPRA offers **a wide range of systems to cover the broad range of** $SiGe_x$ application fields, from R&D to production.

For research and development GESP5-GXR ingeniously combines **absolute thickness measurement** (without assumption) capability - using the Grazing X-rays Reflectance - determination of the **Ge_x composition in layer** - using the option **X-Rays Diffraction** - and **accurate determination of the optical properties** (even graded layers) using the **Gonio-ellipso-Spectro-Photometer**.

For development and pilot line, the SE-5 ellipsometer allows **automated** characterisation of $SiGe_x$ **blank wafers**.

For production the SE-200 ellipsometer allows a **fully automated** characterisation of the $SiGe_x$ **patterned wafers.**
Figure 3 presents mappings performed on a $SiGe_x$ patterned samples. The structure is an homogeneous $SiGe_x$ layer with 9% of Ge, under a Si cap 350 Å thick. The surface roughness and the native oxide are characterised at the same time.

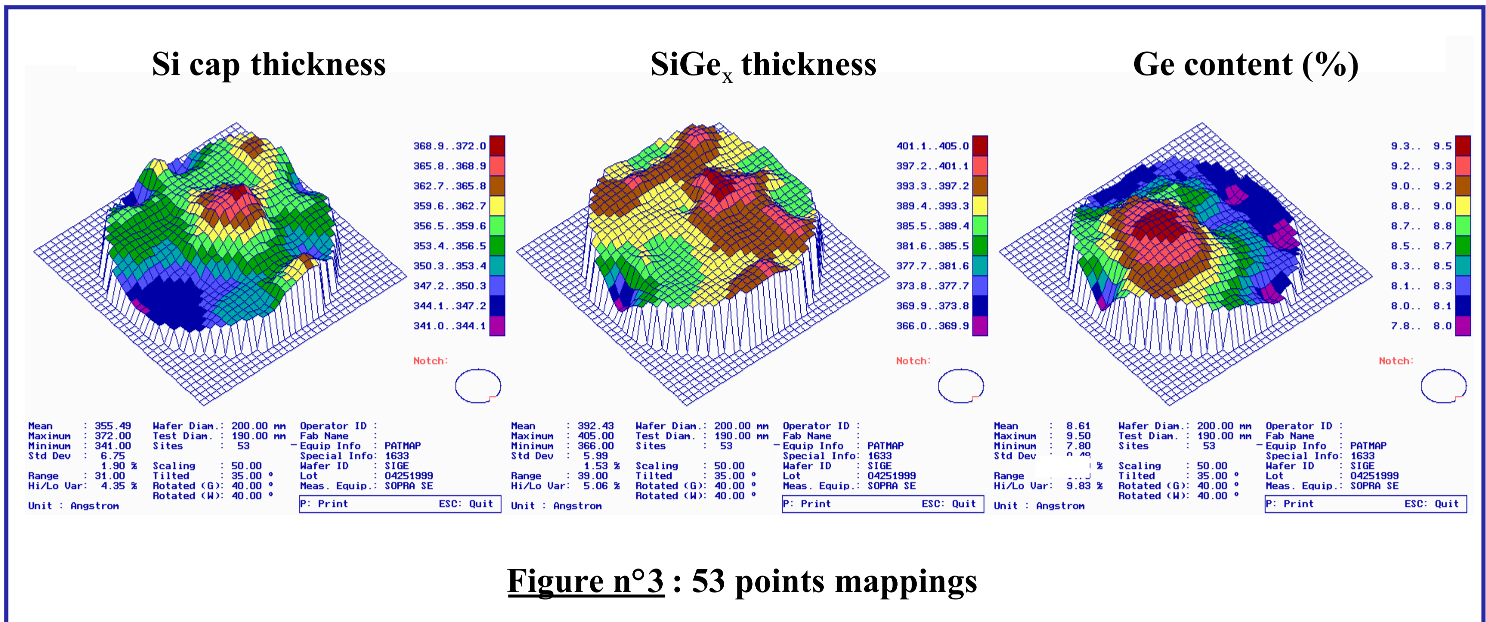

Figure n°3 : 53 points mappings

For Research, Development, Pilot or Production line, SOPRA's Spectroscopic Ellipsometers allow a complete characterisation (thickness, optical properties, composition and gradient determination) of $SiGe_x$ samples.

The same kind of measurement and results can be obtained on similar multilayer compounds samples such as III-V compounds.

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