

This implies, during the method for making the SOI, measuring the thickness of the thin silicon layer and of the electrically insulating layer, in different points of the surface of the SOI, in a wide range of spatial wavelengths, typically comprised between 0.5 μm and 300 mm.

Present measurement methods are based on optical measurements, notably ellipsometry or spectral reflectometry.

In both cases, these methods imply conducting a large number of measurements by illuminating the SOI with a light flux having several optical wavelengths, so as to not only measure the thickness of the silicon layer but also that of the buried oxide layer.

However, with these techniques, it is not possible to conduct measurements with spatial wavelengths as small as 0.5 μm .

Thus, an ellipsometer allows measurements to be conducted with spatial wavelengths greater than or equal to about 40 μm .

On the other hand, these measurements take a long time and are a penalty in the manufacturing cycle of the SOIs.

Moreover, measurements conducted by ellipsometry or reflectometry with a single optical wavelength would not give the possibility of determining with sufficient accuracy the thickness of the silicon layer, since, for a given optical wavelength, the measured thickness of the silicon layer depends on the thickness and on the nature of the underlying buried oxide layer.

~~An object~~Embodiments of the invention ~~is therefore to propose~~seek to provide a method for measuring thickness variations in a layer of a multilayer semiconductor structure, which gives the possibility of conducting measurements in particular in the range of spatial wavelengths comprised between 0.5 and 40 μm , which is not accessible with the present measurement methods.

In particular, said method should allow measurements of thickness variations in the thin silicon layer of an FDSOI structure, with an accuracy at least equal to 0.1 nm.

SHORT DESCRIPTION OF THE INVENTION

~~According to the invention,~~A first aspect of the present invention provides a method is proposed for measuring thickness variations in a layer of a multi-layer semiconductor structure, ~~which~~characterized in that it comprises:

- acquiring, with ~~at least~~ an image acquisition system, at least one image of the surface of said structure, said image being obtained by reflecting a quasi-monochromatic light flux on the surface of said structure,

- processing said at least one acquired image so as to determine, from intensity variations of the light reflected by said surface, the ~~variations of the thickness~~ thickness variations of said layer to be measured,

5 | and in that the wavelength of said quasi-monochromatic light flux ~~being~~ is selected so as to correspond to a minimum of the sensitivity of the reflectivity of the multilayer structure with

respect to a layer of the structure other than the layer for which thickness variations have to be measured.

The said sensitivity of the reflectivity with respect to a layer of the structure, which is homogeneous to the reciprocal of a length, is defined as being the ratio between being equal to the ratio between:

- the difference between the reflectivities of two multilayer structures for which the considered layer has a given thickness difference ~~from one structure to the other~~ (for example 0.1 nm) and

- said given thickness difference,

the thicknesses of the other layers ~~as for them being~~ identical in both multilayer structures.

In other words, both structures targeted above consist of the same layers, said layers having the same thickness in both structures except for the layer for which the sensitivity of the reflectivity is to be measured and to which is assigned a thickness which differs from one structure to the other.

This sensitivity of the reflectivity depends on the wavelength of the light flux used for the measurement.

For the application of the invention, the absolute value of said sensitivity is of interest, the minimum sought sensitivity relatively to a layer other than the layer to be measured being zero or close to 0.

By a "multilayer structure", is meant a structure comprising at least two layers which are transparent at the wavelength of the quasi-monochromatic measurement flux.

By "quasi-monochromatic" is meant a light flux for which the spectrum extends in a range of wavelengths which may extend up to ± 20 nm relatively to a rated wavelength.

When the wavelength of said quasi-monochromatic flux is referred to, reference is made to the rated wavelength. Naturally, a monochromatic light flux, i.e. having a single wavelength, may also be used for applying the invention.

According to an embodiment of the invention, said image acquisition system is an optical microscope.

According to another embodiment, said image acquisition system is a digital photo camera for which the size of a pixel is less than or equal to $0.25 \mu\text{m}$.

Preferably, the numerical aperture of the image acquisition system is greater than or equal to 0.8.

The incidence of the light flux on the surface of the structure is advantageously normal to said surface.

According to an embodiment, said treatment comprises a calculation of a theoretical reflectivity of the multilayer structure depending on the thickness of said layer to be

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measured for the wavelength of the quasi monochromatic flux and the determination, from this calculation, of a mapping of the thickness variations of said layer.

According to an embodiment, said treatment comprises:

- comparing the image with a calibration curve established beforehand, said calibration curve providing a relationship between the grey levels of the acquired image and a local thickness of said layer to be measured, and

- determining, from said calibration curve, a mapping of the thickness variations of the layer on the surface of the structure.

Advantageously, the method comprises, prior to the acquisition of said at least one image, the following steps:

- measuring the thickness of each of the layers of the structure,
- from said measured thickness, simulating the sensitivity of the reflectivity relatively to each of said layers depending on the wavelength of an incident light flux, and

- determining, from said simulation, the wavelength of the quasi-monochromatic light flux intended to illuminate the surface of the structure, said wavelength being selected so as to minimize the sensitivity of the reflectivity with respect to a layer other than the layer to be measured.

Said thickness measurement is advantageously conducted by means of an ellipsometer or reflectometer.

According to a particular application of the invention, the multilayer structure is a structure consisting of two layers transparent to the wavelength of the quasi-monochromatic light flux on a supporting substrate.

In a particularly advantageous way, said multilayer structure is a semiconductor-on-insulator structure comprising a supporting substrate, an electrically insulating layer and a semiconductor layer and the layer for which the thickness variations are measured is said semiconductor layer.

For example, said structure is advantageously an FDSOI structure, the layer for which the thickness variations are measured being a silicon layer having a thickness of less than or equal to 50 nm, preferably less than or equal to 12 nm.

~~Another object relates to~~ Embodiments of the present invention also seek to provide a measurement system allowing the application of the method described above.

~~Said~~ A second aspect of the present invention provides a system for measuring thickness variations in a layer of a multilayer semiconductor structure, characterized in that it comprises:

- a device for illuminating the structure, adapted for emitting a quasi-monochromatic light flux towards the surface of said structure,

- a device for selecting the wavelength of the quasi-monochromatic light flux, configured for determining a wavelength corresponding to a minimum of the sensitivity of the reflectivity relatively with respect to a layer of the structure other than the layer for which the thickness variations have to be measured, said sensitivity of the reflectivity relatively with respect to a layer being equal to the ratio between:

- the difference between the reflectivities of two multilayer structures for which the considered layer has a given thickness difference, and

- said given thickness difference,

the thicknesses of the other layers ~~as for them~~ being identical in both multilayer structures,

said selection device being coupled with the illumination device ~~in order so as~~ to provide to said illumination device with said determined wavelength of the light flux to be emitted,

- an image acquisition system laid out so as to acquire at least one image of the surface of the structure by reflection of said quasi-monochromatic light flux,

- a processing system configured for ~~determining~~, from said at least one acquired image, ~~and from determining from the~~ intensity variations of the light reflected by said surface, ~~the thickness variations~~ variations of the thickness of said layer to be measured.

According to an embodiment, the illumination device comprises a source of white light and a wheel supporting a plurality of filters having different wavelengths, the wheel being adapted for rotating so that the light emitted by said source passes through a filter having the wavelength determined by the selection device before attaining the surface of the structure to be measured.

According to another embodiment, the illumination device comprises a plurality of light sources each having a different wavelength and a plurality of the removable obturators coupled with said sources and laid out so as to only let through the light having the wavelength determined by the selection device towards the surface of the structure to be measured.

SHORT DESCRIPTION OF THE DRAWINGS

Other features and advantages of the invention will become apparent from the detailed description which follows, with reference to the appended drawings wherein:

- Fig. 1 is a sectional view of a multilayer structure, for which an attempt is made for measuring the thickness variations of one of the layers,
- Fig. 2 schematically illustrates the reflections occurring in two layers of a multilayer structure,
- Fig. 3 shows the curves of the sensitivity of the reflectivity of an FDSOI structure, versus the wavelength, relatively to the thin silicon layer (curves Si1 and Si2) and relatively to the buried oxide layer (curves BOX1 and BOX2),
- Fig. 4 shows a calibration curve of an optical microscope which may be applied in the invention,
- Figs. 5A and 5B illustrate optical microscopy images acquired for two FDSOI structures and Figs. 5C and 5D show thickness mappings of the thin silicon layer obtained for each of said structures respectively,