Characterization of compound semiconductors by combined spectroscopic ellipsometry and grazing x-ray reflectance.

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Characterization of semiconductor compounds in complex epitaxial structures can be extremely difficult when the layers include more than two elements and the number of layers become important. Spectroscopic ellipsometry (SE) has long been recognized has a powerful technique to extract simultaneously the thickness and composition of such layers. The occurrence of different optical transitions in the visible range and their wavelength positions are directly related to the structural quality and composition of such layers. For photonics applications, additional optical coatings like antireflective coatings, mirrors or filter are generally deposited on top of the semiconductor structures and can be characterized by the same technique.

The proposed paper uses an automated combined system including spectroscopic ellipsometry and grazing x-ray reflectance (GXR). The spectroscopic ellipsometer is working in the wavelength range 0.19-2.05µm from deep uv to near infrared. Deep uv is useful to analyze the top surface of the sample due to the strong optical absorption. On the contrary, near infrared can check the stacks down to the substrate when the transparency of the layers is larger. A microspot option is available on the instrument to reduce the size of the measurement zone down to 200µm. It is combined on the same optical setup with a grazing x-ray reflectometer working at 0.154nm (Copper K-alpha). This technique can provide directly the thickness of layers from the position of the interference fringes versus the angle of incidence. The measurement is also very sensitive to interface and surface roughness and so very complementary to spectroscopic ellipsometry. Both type of measurements are analysed simultaneously using the same optical model adjusting thickness on GXR compositions on SE. The measurement tool is included in an automatic environment with 300mm wafer handling and orientation, XYZ table, pattern recognition and autofocus, and capable to work in a completely automated way for device control.

The analysis of a complex epitaxial structures including two different GaInAsP layers on InP substrate with a top protective InP layer is reported in Figure 1. In this case, the accuracy of the SE measurement is sufficient to provide the thickness of all the layers including the top native oxide layer with a good accuracy. On laser facet, deposition of optical coatings with specific properties is generally required. SE can provide precise information on these kind of coatings as shown in Figure 2 for a complex antireflective coating at 1.55µm. Accurate determination of the different oxide thickness allow to predict precisely the reflecting properties of the coatings in the entire wavelength range used for the SE measurement.

The proposed paper will present this new system with some examples of applications on GaAs, InGaAs, AlGaAs and InGaAsP structures and additional optical coatings.

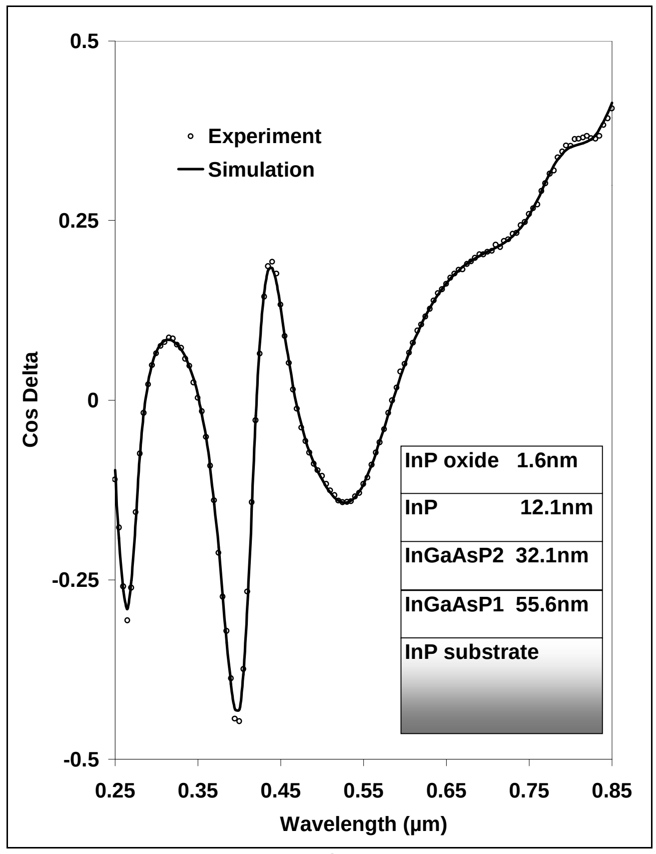

Figure 1: Characterization of a complex epitaxial structure.

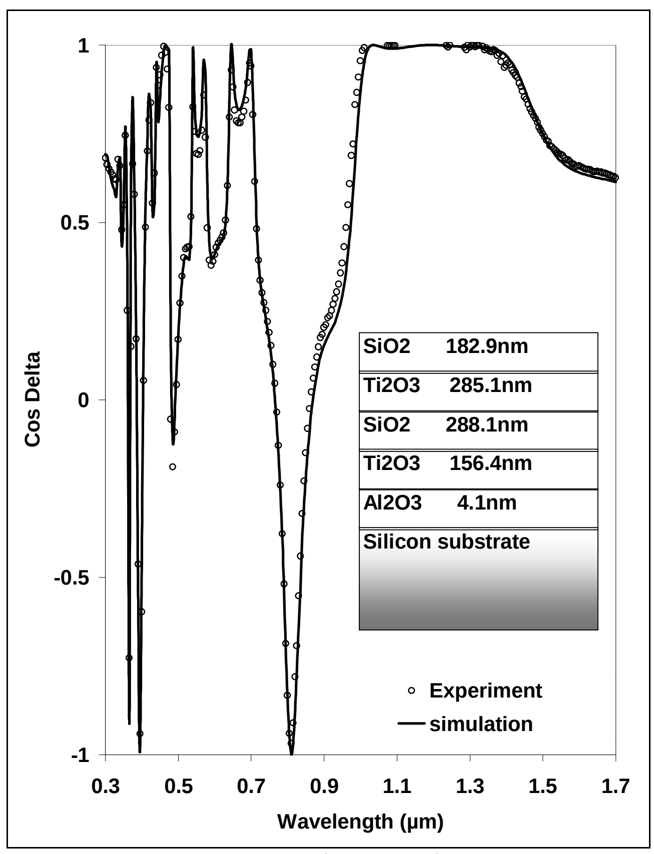

Figure 2: Characterization of an antireflective coating at 1.55µm for laser facet.