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Determination of the surface region structure from ellipsometric data

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The problem of choice of a system model and determination of this system parameters from experimental data obtained by reflective ellipsometry have been considered. The multi-angle ellipsometric studies of dielectric HfO_2 films on optical glasses, and the natural oxide ones on Ge surface have been carried out. The calculations for the bilayer model allow to determine that for HfO_2 deposition on optical glass by electron beam sputtering of the coating material, interlayer is formed between the film and substrate having the refractive index considerably different from that of the glass. In the case of the oxide film on germanium, the angle of incidence dependence of the determined parameters can be eliminated by proper choice of the substrate optical constants.

Рассмотрена проблема выбора модели системы и определения параметров этой системы из экспериментальных данных, полученных отражательной эллипсометрией. Проведены многоугловые эллипсометрические исследования диэлектрических пленок HfO_2 на оптических стеклах и естественного окисла на поверхности германия. Расчеты для двухслойной модели показали, что при осаждении HfO_2 на оптическом стекле с электронно-лучевым распылением материала покрытия между пленкой и подложкой образуется промежуточный слой, показатель преломления которого значительно отличается от показателя преломления стекла. В случае оксидной пленки на германии зависимость определяемых параметров от угла падения можно исключить путем правильного подбора оптических констант подложки.

The real reflection systems, used in engineering (for example, films on substrates obtained by different methods), can have a complex structure and parameters of separate system components which are to be determed in experiment. The reflection system model describing it in all details is unknown, and must be rather complicated.

To determine a plenty of unknown parameters of the reflection system, it is necessary to carry out experiments under different fixed conditions (angle of incidence, the film thickness, etc.). In case of the ellipsometric measurements, the full information on the reflective system is born by the ellipsometric function, dependence of the ellipsometric angle on that of incidence. Measurements are carried out for several angles of incidence. On a result, some equations are obtained which are to be solved to determine the unknown system parameters, the film thickness and optical constants of coating layers and substrate.

The problem consists in that the ellipsometric equation connecting the ellipsometric angles with unknown parameters, is nonlinear and transcendental and it cannot be solved explicity with respect to the unknown parameters. Therefore, to solve the ellipsometric equation, iteration methods are usually used, that are effective in the case of a simple single-layer systems [1], when a film are rather thick, so that measured ellipsometric angle values are far from those for the free substrate. For complex reflection systems where many parameters, are to be determined, the ellipsometric function converges poorly and the iteration methods do not work.

In this study, manifestations of the reflection system complicated structure in particular, of an interlayer are considered