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In Situ Spectral Magnetoellipsometry for Structural, Magnetic and Optical Properties of Me/Si (Me = Mn, Fe) Nanolayers

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In our work we present in-situ spectral magnetoellipsometer is equipped with sapphire manipulator. which allows us to carry out in-situ and in-time optical and magnetooptical measurements in the range from 10 K to 1500 K in spectral range 1.5 eV-4.0 eV (830 nm-300 nm), the range of magnetic fields is +/- 0.4 T.

Keywords: Ellipsometry, Kerr Effect, In-situ, Magnetic Structures, Multilayers.

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In recent years the interest in multilayer magnetic structures Ferromagnetic/Semiconductor has increased owing to their unique physical properties and prospect for practical application. Structures Mn/Si, Fe/Si combine the electronic transport properties of semiconductors and memory characteristics of magnetic materials.

The complementary properties of semiconductor and ferromagnetic material can manipulate both degrees of freedoms of electrons' spins and charges for spintronic devices. The Si-based nanostructures attract considerable experimental effort due to the compatibility with mainstream silicon technology.

In our work we present the investigation of structural, magnetic and optical properties of Me/Si (Me = Mn,Fe) nanostructures on Si (100) substrate by in situ generalized magneto-optical ellipsometry. The measurements were performed by spectroscopic and one-wave laser ellipsometers ("Spectroscan" and "LEF-71" respectively by Institute Semiconductors Physics SD RAS), modified to measure not only traditional ellipsometric parameters, but also magneto-optical response of the sample. The magnetoellipsometers were integrated into the ultrahigh vacuum chambers of molecular beam epitaxy setup [1], which allowed to control the optical and magnetic properties of thin films directly in the growth process. As a result of the magneto-optical response analysis, it was found that iron and manganese silicides in magnetic phase were formed on the Si surface and by analysis of the ellipsometric parameters Δ and Ψ dependence on evaporation time the silicide nanoclusters were identified and their structural properties were found. Magnetic hysteresis loop for Fe/Si has been obtained. From spectral dependence of parameter Δ in Fe film we have measured the Stoner gap between spin majority and spin minority electrons.

In-situ spectral magnetoellipsometer is equipped with sapphire manipulator. which allows us to carry out measurements in the range from 10 K to 1500 K since the sapphire thermal conductivity decreases of about 2000 times. This enables us to effectively remove heat from the sample at a low temperature and prevent heat removal when heated.

Spectral range of magnetoellipsometer is 1.5 eV-4.0 eV (830 nm-300 nm). The range of magnetic fields is +/-0.4T.

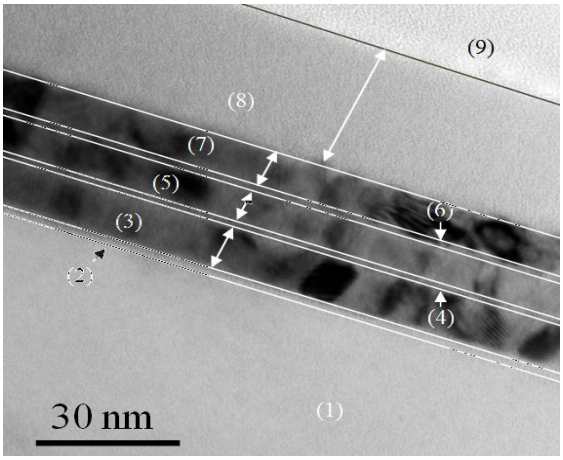

Fig. 1 – Cross-section TEM image of Fe56/Fe57/Si)3/SiO2/Si(100) multilayer structure.

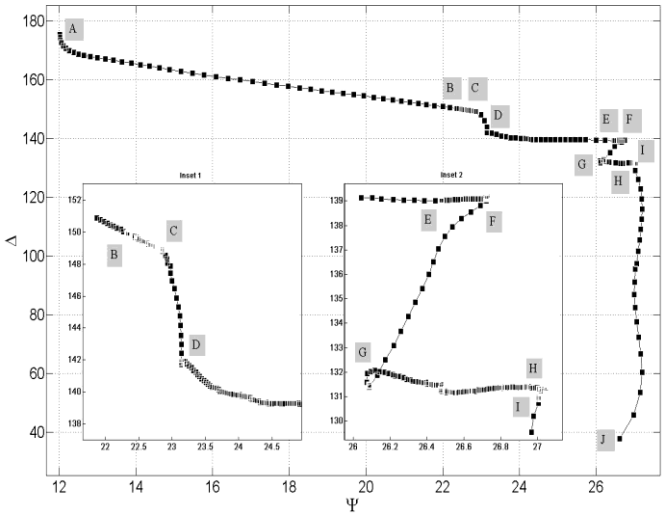

Fig. 2 – The trajectory of ellipsometric angles changing during the (Fe56/Fe57/Si)3/SiO2/Si(100) multilayer structure deposition. A – The beginning of the first Fe56 layer deposition, B – the ending of the Fe56 layer deposition and t he beginning of the first Fe57 layer deposition, C – the ending of the Fe57 layer deposition and the beginning of the first Si layer deposition, D – the ending of the Si layer deposition and the beginning of the second Fe56 layer deposition, E – the ending of the Fe56 layer deposition and the beginning of the second Fe57 layer deposition, F – the ending of the Fe57 layer deposition and the beginning of the second Si layer deposition, G – the ending of the Si layer deposition and the beginning of the third Fe56 layer deposition, H – the ending of the Fe56 layer deposition and the beginning of the third Fe57 layer deposition, I – the ending of the Fe57 layer deposition and the beginning of the third protective Si layer deposition, J – the ending of protective Si layer deposition. The inset 1 reveals an extended view of the BCD part of general ellipsometric nomogram, the inset 2 – the EFGHI part.

REFERENCES

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