Tulinov Symposium, Moscow, May 2020

**Quantification and Applications of Low-Energy Ion Scattering**

Hidde H. Brongersma1,2, Philipp Brüner1, Thomas Grehl1, Stanislav Průša3

1IONTOF GmbH, Münster, Germany

2Eindhoven University of Technology, Eindhoven, The Netherlands

3Brno University of Technology, CEITEC, Brno, Czech Republic

The outermost atoms of a surface largely control processes such as growth, nucleation, poisoning and electron emission. Precisely these outer atoms can preferentially and quantitatively be analyzed with Low-Energy Ion Scattering (LEIS). This has opened many new applications for microelectronics, sensors, catalysis and anti-wetting [1]. Since typical ion energies are between 1 and 10 keV, the impact will damage the surface. Thus to take full advantage of the monolayer sensitivity of LEIS, one should use such low ion fluences that the analysis is essentially non-destructive (“static”). Since the early days of LEIS, about 50 years ago, an important objective has therefore been to improve the sensitivity of the LEIS instruments. The latest development is the Qtac100, which uses parallel energy detection and a full 2π azimuthal acceptance for the backscattered ions. This instrument has been used for the present applications.

Since matrix effects are generally absent or relatively small in LEIS, a quantitative analysis is straightforward [2]. LEIS is applicable to any type of sample that can be taken into vacuum. It is just as well suited for the analysis of amorphous, insulating, extremely rough surfaces as for conducting, flat single crystals. However, the theory to quantitatively predict the atomic sensitivities of the elements falls short. Although in recent years significant progress has been made in the understanding of neutralization and reionization, an accurate analysis of the surface composition still requires well-defined reference materials. A complication being that the composition of the outer atomic layer of a material is generally fundamentally different from that of the atoms below this surface. As an example, it will be shown how the F/Ca atomic ratio for the outer surface of a CaF2 powder has been determined.

In addition to the scattering by the outer surface, LEIS can also be used for non-destructive analysis of the deeper layers (0 – 10 nm) [3]. This process is similar to that of Rutherford (MeV) backscattering, but has a superior depth resolution.

As an example, the ALD growth of GaSb on a SiO2 substrate is followed using He+ and Ne+ ion scattering. For the early stages of the growth the layer closure is determined. Also, an interesting oscillation in the Ga/Sb stoichiometry is observed.

[1] H.H. Brongersma, Low-Energy Ion Scattering, in: “Characterization of materials”,

Ed. E.N. Kaufmann, pp. 2024-2044.

[2] V.S. Chernysh, H.H. Brongersma, P. Brüner, T. Grehl, Nucl. Instr. Meth. **B 460** (2019)

180-184.

[3] P. Brüner et al., J. Vac. Sci. Technol. **A33**, 01A122-1-7.