Technical Note: Low Energy Ion Scattering (LEIS)

Low Energy Ion Scattering (LEIS) probes the elemental composition of the outermost atomic layer of a surface. It is therefore an extremely surface sensitive analytical tool. Detection limits are in the 10 ppm range for heavy elements and in the percent range for light elements. The following information can be obtained by LEIS:

- **Atomic composition and surface coverage in the outermost atomic layer**
- **Depth analysis with 1 nm resolution**
- **Quantitative information at the atomic level**

Various material classes like metals, metal oxides, ceramics, paints, polymers and glass can be investigated. The main application areas include catalysis and monitoring surface modifications (atomic layer deposition, modified glass, self-assembled monolayers, surface active metals, etc.).

In a LEIS experiment, the surface to be analyzed is bombarded by noble gas ions of some keV energy (marked in purple in Figure 1.)

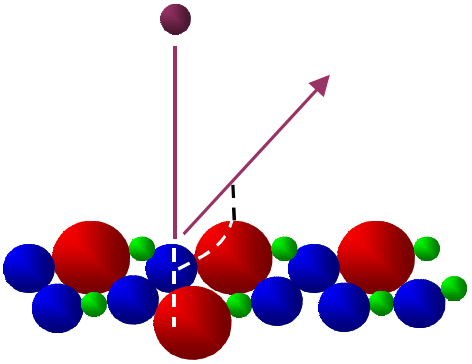

Figure 1. Schematic of a LEIS experiment.

These ions are scattered by the atoms in the top-most layer of the sample. The energy after the scattering process is mainly determined by the masses of the scattering partners. Thus, by determination of the energy of the scattered ions, the scattering partner at the surface can be identified (see Figure 2).

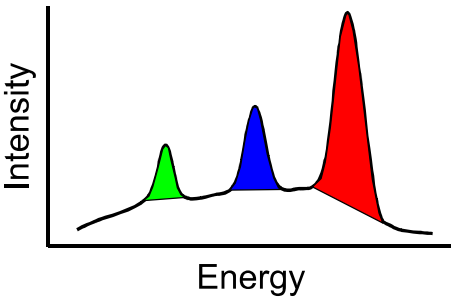

Figure 2. LEIS spectrum of the scattering experiment shown in Figure 1.

The yield of ions backscattered from the surface is a measure for the atomic surface concentration. However, for absolute values, a comparison with data taken from standard materials is necessary.

Primary projectiles can also be scattered in deeper layers. In these processes they loose additional energy which results in a characteristic background signal towards lower energies compared to the surface peak. By evaluating such data information on the depth distribution of thin layers can be obtained (static LEIS depth profile) with a very high depth resolution (1 atom – 1 nm).

Figure 3 shows an example for such an analysis. The blue curve represents Ba situated only in the topmost layer of the polymer poly(phenylene vinylene) (PPV). The peak shows a shape typical of scattering at the outermost

atomic layer (surface) and no background signal. The red curve corresponds to Ba being present both at the surface and in the near surface layers of the bulk PPV. In this case, addition to the surface peak, a tail is detected towards lower energies. Modelling the energy loss in organic layers the maximum depth of the Ba diffusion can be determined to be 7 nm.

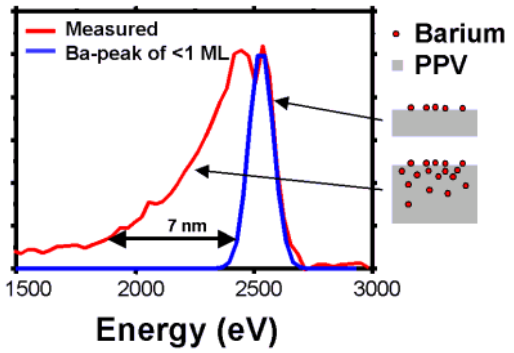

Figure 3. Ba signal in the LEIS spectra of two different poly(phenylene vinylene) (PPV) samples; blue curve: Ba present in the outermost layer only; red curve: Ba additionally present in the bulk.

Being a very surface sensitive technique, LEIS results may suffer from surface contaminants. However, in-situ surface cleaning leads to good results in most cases.

Generally, all types of solids can be analyzed including powders, insulators, and rough samples. The following list shows recent application areas:

- Catalysts
- Cathodes
- Coatings
- ALD growth
- Diffusion barriers
- Fibers
- Fuel cells
- High-k dielectrics
- Implants
- Light bulbs
- Linoleum
- MEMS
- Paint
- Paper
- Polymer LEDs
- X-ray tubes

Figure 4. ION-TOF Qtac^{100} Instrument

TASCON uses instrumentation first developed by Prof. Brongersma at Calipso in the Netherlands and now marketed by ION-TOF (Qtac^{100}). The analzyer design of these instruments ensures a high sensitivity and high mass resolution, thus giving superior detection limits compared to conventional ion scattering instruments.