

Quantitative low energy ion scattering: Achievements and challenges

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Since its beginning some fifty years ago, Low Energy Ion Scattering (LEIS) developed to a widely used tool for analysis of structure and composition of solid surfaces, see, e.g., [1-5]. Two features contribute to the success of LEIS: first, its superb surface sensitivity and second, the fact that for most applications the yield of ions backscattered from one atomic species is independent of the other atoms present in the surface (“*absence of matrix effects*”, [5-7]).

Quantitative surface composition analysis is based on accurate knowledge of the *fraction of ions* amongst the backscattered particles, P^+ , and the *differential scattering cross section*, $d\sigma/d\Omega$. For that, the influence of electronic screening on nuclear scattering must be modelled precisely; the *universal potential* has been shown to be a good choice as long as not too low ion energies and too large impact parameters are employed [8]. To apprehend why in general LEIS is not sensitive to band structure effects requires understanding of the prevailing charge exchange processes – mainly *Auger neutralization* along the trajectory and *resonant charge exchange (neutralization or reionization)* in a collision [5]. Recently, it has been demonstrated that due to distinct neutralization efficiencies of different allotropic forms of carbon [9] the concentration of organic carbon on graphene can be quantified [10].

Very recently, interesting LEIS applications to ultrathin subsurface layers were reported. To gain quantitative information in this case one has to successfully handle additional processes: electronic stopping and processes related to multiple scattering: depth-dependent angular spread, increase in path length, and the loss of the unique relationship between final energy and scattering depth for a specific collision partner. To achieve quantification nevertheless, MC-simulations are required.

It will be summarized how quantitative information on P^+ can be obtained, how quantification of surface composition can be achieved, and which questions are still open [11, 12].

- [1] V. Walther and H. Hintenberger, Z. Naturforschg. 18a, 843 – 853 (1963).
- [2] S. Datz and C. Snoek, Phys. Rev. 134, A347 – A355 (1964).
- [3] D.P. Smith, J. Appl. Phys. 38, 340 – 347 (1967).
- [4] J. O’Connor in *Surface and Interface Science*, vol. 1, 269 – 310, Wiley VCH (2012), ed. K. Wandelt.
- [5] H.H. Brongersma et al., Surface Science Reports 62, 63 – 109 (2007).
- [6] H.H. Brongersma and P.M.Mul, Chem. Phys. Lett. 14, 380 – 384 (1972).
- [7] W. Heiland and E.Taglauer, J. Vac. Sci. Techn. 9, 620 – 623 (1972).

- [8] D. Primetzhofer et al., Nucl. Instr.Meth. 269, 1292 – 1295 (2011).
- [9] S.N. Mikhailov et al., Nucl. Instr. Meth. B93, 210 – 214 (1994).
- [10] S. Prusa et al., Langmuir 31, 9628 – 9635 (2015).
- [11] P. Bruner et al., J. Vac. Sci. Techn. A33, 01A122-1 – 01A122-7 (2015).
- [12] D. Goebel et al., Nucl. Instr. Meth. B354, 3 – 8 (2015).