High sensitivity to microstructure variations at different depths in thin surface layers

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Irradiation-induced defect concentration has been investigated with high precision using laboratory equipment for the construction material targeted for the generation IV of the nuclear power reactors. The *defect density profile* as the function of depth under the specimen's surface could be obtained thanks to application of the *grazing exit diffraction* (GED) geometry instead of fixing the primary X-Rays incidence angle (GID, Fig. 1A). The crystal lattice gets heavily damaged after the ODS steel (oxide dispersion-strengthened steel, Y_2O_3-$Fe_{0.8}(Cr,Al,Ti,V)_{0.2}$) is subjected at 300°C to implantation of 10 MeV Fe^{2+} ions up to the dose of 5 dpa (displacements per atom, i.e. fluence 5×10^{15} ions/cm^2) [1].
Utilisation of ions in place of neutrons mimics the irradiation effects well enough and the specimen does not become radioactive [2]. Ion implantation also speeds up the experiment as the target dose is reached in much shorter time due to the higher ion-material interaction cross section. However, for the same reason the *affected volume of the material is limited to a shallow layer under its surface*. The expected defect density profile (Fig. 1B) can be estimated using e.g. the SRIM (Stopping and Range of Ions in Matter) software [3].
Thus, the need for studies evaluating *contribution from consecutive depths* (arrows in Fig. 1B) and *affording sensitivity to microstructure variations* arises. Employment of GED geometry combining θ scans (Fig. 1C) with fixed low collection angle and narrow collimation in the detector optics provides *ultimately small* contribution of the *instrumental resolution function* (IRF, Fig. 1D) to the diffraction profile. Hence, when working with the semi-parallel beam reflected from the Göbel mirror, the issues bound to GID geometry are readily solved:

- there is no requirement to use the analyser crystal (data quality at the expense of photon flux at the detector);
- nor the angular resolution is compromised by the alternative Parrish-Hart analyser slits (a.k.a. equatorial Soller slits) offering usually a too large opening angle.

Furthermore, the GED θ scan allows setting a much larger primary slit at the X-Ray source because the beam footprint becomes much smaller at the HKL peaks acquisition angles while the field of view of the detection system covers large-enough area.

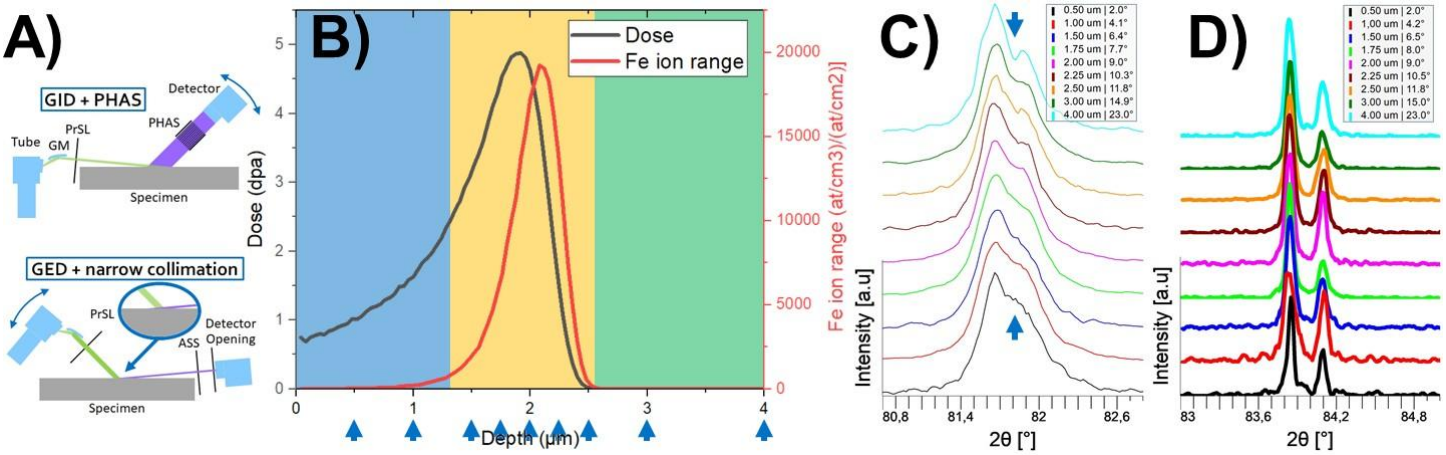


Figure 1. *The GID and GED geometries schemes (A). The damage and the deposited ion concentration depth profiles in the irradiated ODS steel (B). The ODS steel (BCC 2 1 1, C) and LaB_6 (3 2 0, D) exit angle-dependent GED peak profiles.*

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