Nanostructure of Nafion membrane

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Abstract. Nafion® 117 by DuPont is a commercial polymer membrane material that is frequently used in fuel cells. Because of its well–defined separation characteristics we use it as a reference material. There are numerous SAXS and SANS studies on this material that have been performed in order to understand its complex nanostructure. Now we use the new 2D MarCCD detector of beamline A2 and study the material in straining cycles with respect to both the machine and the transverse direction of the film. We confirm reported MAXS and SAXS features. We find that already the original material is oriented. We find a characteristic pointed SAXS peak on the meridian only in the strained state. We find that structure becomes different when strained in different direction. We still have problems with the quantitative analysis of the data because of the superposition of SAXS and MAXS in the pattern. We are working on the problem of separating SAXS and MAXS.

Experimental. SAXS was performed at HASYLAB, A2. 2D SAXS images were collected by a two-dimensional MarCCD 185 detector. The sample–to–detector distance was 1620 mm. An advanced pin diode beam stop was successfully employed. In order to record data with a sufficient S/N-ratio the sample was exposed for 5 min to 10 min (in the strained state). The accessible data range was $-0.4\ nm^{-1} < s_{12}, s_3 < 0.4\ nm^{-1}$.

Results and Discussion. Some of the recorded SAXS/MAXS patterns are shown in Figure 1. The original material shows a strong SAXS reflection in the center and an anisotropic MAXS reflection with its maximum about the equator close to the edge of the sensitive area of the detector. The combined SAXS/MAXS features were first reported by Fujimura et. al. [1] and assigned to a semicrystalline structure and the scattering of ion clusters. In a second study [2] they conclude that the discrimination between a two–phase model and a core–shell model for the structure of the ion clusters is difficult. Later work is mostly limited to a discussion of scattering curves. An exception is a paper of Haubold et al. [3] in which a nanostructure model is presented that fits the scattering curve.

References

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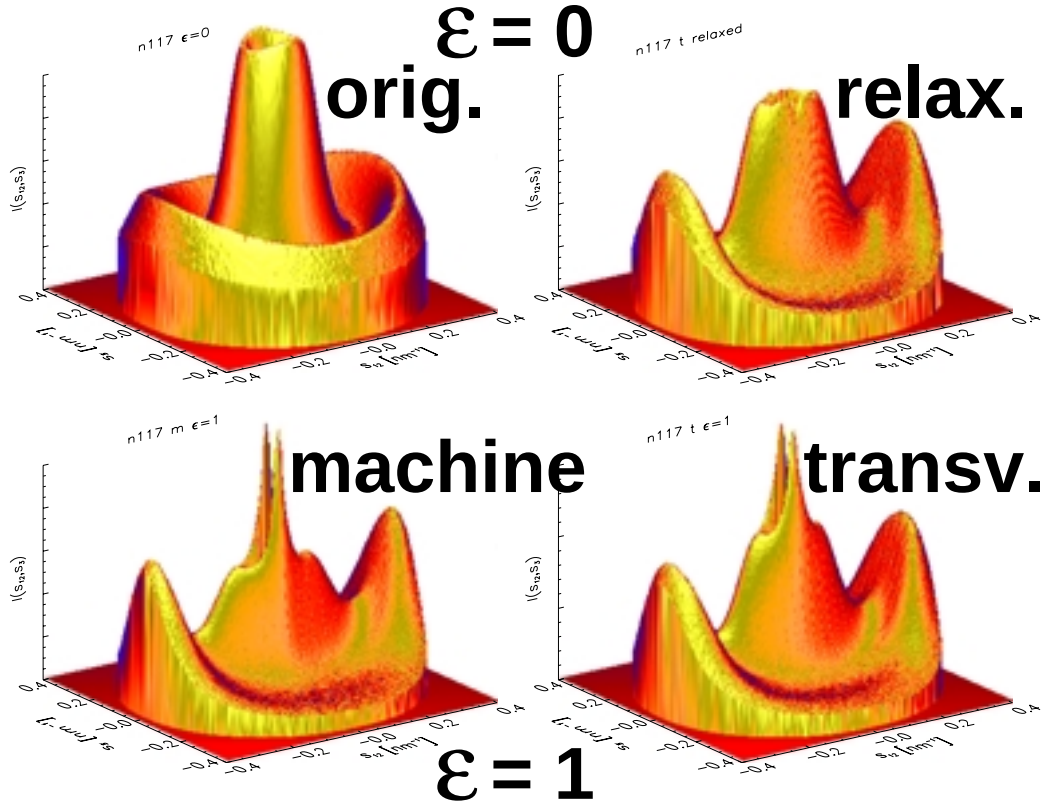

Figure 1: Nafion 117 film. Measured SAXS intensity before, during and after straining to $\epsilon = 1$. The bottom diagrams are labelled with the chosen straining direction with respect to the orientation of the film material.