Appendix D : Proton Detection with CR39/TASTRAK

D1 Detection and Processing

The detection material is a clear plastic (polydiethylene-glycolbisallylcarbonate), well known as CR 39 (trademark of PPG Industries, Inc.) or TASTRAK (TASL Track Analysis Systems Ltd., Bristol UK [TASL02]). For the experiments presented here material from TASL in slices of (50 × 50 ×1)mm was used. CR 39[1] was developed in 1933 and is actually a material for making spectacle lenses [TASL02]. In 1978 its sensitivity to particle radiation was discovered [CRC78]. In principle, charged particles create nm-wide tracks in the bulk material. The length of these tracks is defined by the particles' mass and energy. The tracks are widened by an etching process (Fig. D-1) using concentrated hot NaOH. Typical processing parameter are: etching time 1-8 hours, temperature 50-96°C, and NaOH concentration 6.25 N. In the etching process not only the tracks are widened but also bulk material is removed. Thus, badly chosen etching parameters can lead to a complete removal of the tracks. The track edge rate v_t should be larger than the bulk etch rate v_b to avoid the problem. The relation v_t/v_b maximizes with increasing temperature [FH82]. In our experiments we used 96° and 1 hour for the etching process.

Extensive investigations on the proton impact and etching conditions found a relation between track diameter and particle energy [DFH97]. Although we saw a similar tendency of decrease

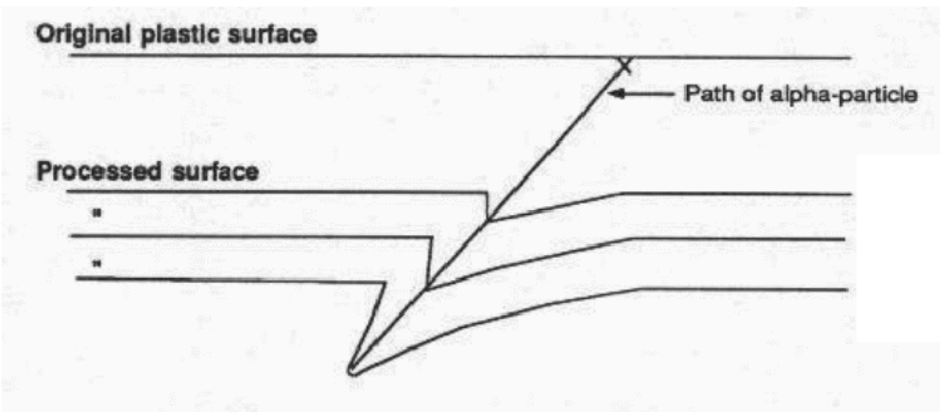

Fig. D-1 : Schematic of the etching process of the TASTRAK material [TASL02**].**

[1] Since the name CR39 is the more common it will be used throughout this work to denote the detector material.

in track diameter with increasing proton energy, in the experiments presented here the track diameter was not exploited for particle-energy estimation. This would require an energy calibration as well as sub-micron microscopy.

D2 Microscopic Evaluation

After etching the plastic slides were analyzed with an OLYMPUS VANOX AHBT3 optical microscope with adapted Panasonic F15HS video-camera. The typical magnification used was 100 times. It turned out that areas, where the unarmed eye recognizes a white structure (see Fig. 6-9), are typically overexposed. Overexposed (see Fig. D-2 a) means here, that the whole area is filled with tracks and a superposition of several tracks cannot be excluded. Hence, for a proper measurement exposure conditions have to be chosen such that the area of interest is not completely filled with tracks (Fig. D-2b).

For the determination of track numbers (tracks per mm²), areas from 20 × 20 µm² up to 200×200 µm² were defined in a distance of about 1 mm on the plastic slices. The tracks were counted manually on the screen connected to the microscope and track numbers extrapolated.

A separation between hydrogen ions and oxygen ions was possible simply by their size: the larger particles leave tracks which are two or three times larger than the largest proton track. This was proven in separate measurements with a magnet spectrometer by M. Schnürer and S. Busch [MS02].

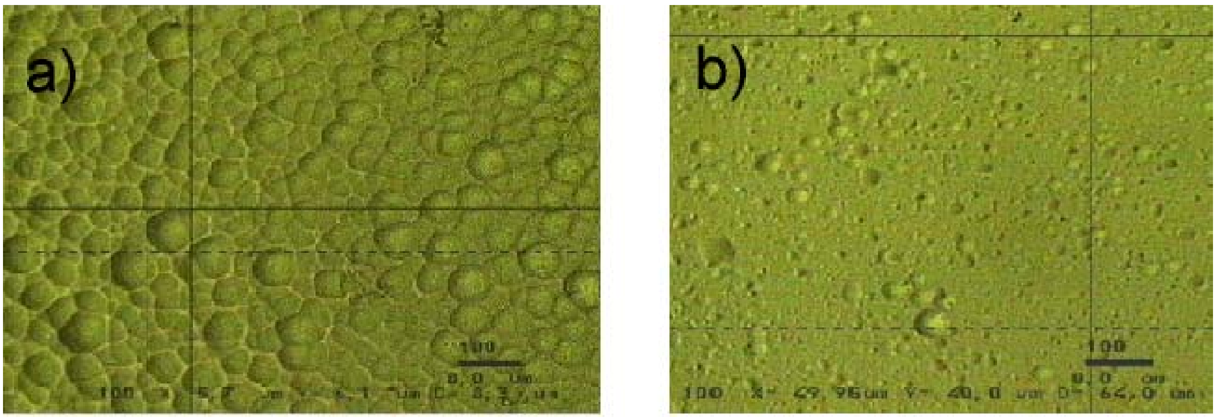

Fig. D-2 : Magnified (100x) images of etched plastics with proton tracks. The scale bar corresponds to 8 µm. Image a) is overexposed, image b) can be utilized for proton-track counting.