

Determination of target line density

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For many experiments investigating the interaction between heavy ion beams and matter, such as determination of charge state distribution or inducing hydrodynamic reactions and shock waves, the precise knowledge of the target's line density distribution is of importance. As for bulk materials, such as plain metal solids, this value is well known, however for self prepared targets, such as rare gas crystals or silica aerogel foams, these parameters have to be defined for each individual sample and should be controlled during the fabrication process. Furthermore, such sensible targets often change their properties during the experiment, leading to misinterpretation of the results, obtained. Thus, a versatile setup has been installed to measure the target line density ρx of rare gas crystals and other target materials in an image-giving way, as shown in Fig 1. Integrated target line density is being determined by x-ray absorption, using Lambert-Beer's law $I = I_0 e^{-\kappa x}$, where κ represents the density (and wavelength) dependent absorption coefficient. A commercial 50kV x-ray source is used to illuminate the target with x-ray radiation. The transmitted radiation is converted into visible light by a phosphor screen, which in turn is being observed by an intensified camera, giving a two dimensional picture of the relative line density distribution of the target. Since the absorption, as well as the response function of the phosphor screen is wavelength dependent, an absolute measure of the line density cannot be obtained by a pure light intensity measurement. A pinhole aperture may thus additionally be installed, defining a single sight line at the target, on which the transmitted x-ray spectrum can be measured, e.g. by a SiLi x-ray detector. A phosphor brightness normalization along that sight line then can be performed.

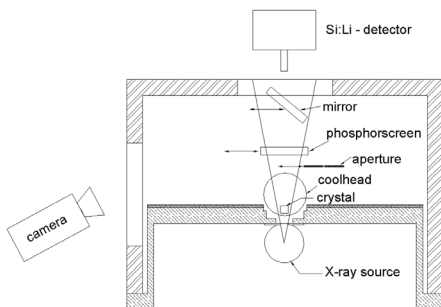


Figure 1: Schematic x-ray transmission setup. The target material (rare gas crystals, aerogel foam, etc.) is irradiated by x-rays. The transmitted x-ray intensity is being converted into visible light by a phosphor, which is being observed by a intensified camera.

As a first sample, a $0.1\text{g}/\text{cm}^3$ silica aerogel target, used during an UNILAC beamtime in order to measure charge state distribution inside matter, was investigated. Before ion beam irradiation, this target was

a 2.6mm thick, homogeneous block. During the ion beam experiment, caverns developed on both sides at the beam-target interaction area, reaching a depth of 0.4mm each, after about 10h of beam irradiation and a total fluence of 10^{14} ions/ cm^2 . Space resolved data, gained in that particular experiment, were severely deteriorated, since the important absolute position of the beam-target interaction surface has changed during data acquisition due to cavern formation. To avoid this effect in following experiments, the formation mechanism of the caverns had to be known. Essentially two possibilities were considered: Sputtering and/or sublimation of Si and O atoms from the target surface, which would result in a decreased line density by leaving the bulk material unchanged and just decreasing the thickness, or collapsing of the aerogel structure due to partially melting, which would keep the line density unchanged.

The result of the transmission measurement is shown in Fig 2. As can be seen, the x-ray absorption in the beam-target interaction region is *higher* than in the undisturbed target material, indicating a *higher* line density in spite of *reduced* thickness. A thin rim of reduced line density can be found at the edge of the interaction volume. Integrating over the entire region of enhanced and reduced absorption, the average mass covering was found to be constant. No sputtering thus has occurred and a partially melting and collapsing process took place, acquiring material from the surrounding into the beam heated volume. A reduced UNILAC beam pulse intensity during the following experiments could avoid this melting, improving significantly the accuracy of the data, obtained.

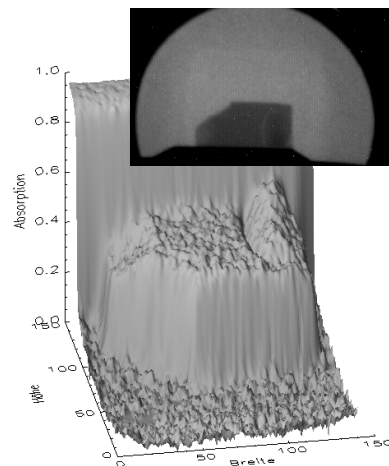


Figure 2: The x-ray intensity, transmitted through an aerogel target after ion beam irradiation is shown (insert). Higher absorption (increased line density) is seen at the interaction region.