Development of mini-focusing small-angle neutron scattering instrument

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By using a neutron focusing device, one can build a short focusing small-angle neutron scattering (SANS) instrument without loosing intensity in theory. It is because sample size could be as large as one at a normal pin-hole SANS instrument. We have developed a compact focusing SANS instrument (mfSANS) by using an ellipsoidal mirror and successfully obtained data of standard samples and steel and other metals with nanoscopic structures in them.

The focusing mirror is 900 mm in length, 20 mm in short radius and only a part of the ellipsoid, about 1/6 of the arc, is used. The length between the two focal points of the mirror is 2.5 m. We put a small pinhole at one of the focal points and put a high position resolution detector at the other end. The detector is a ZnS scintillator coupled with a resistive wire type photomultiplier tube. The sample position of the instrument is at downstream of the focusing mirror and the scattering flight path is about 700 mm. Because of this short flight path, it is easy to install a large solid angle intermediate angle detector bank. We put 6 boxes each with eight He-3 gas linear position sensitive detector tubes.

We have developed a new type of monochromator based on strongly bent perfect silicone crystal plates. We bent the crystal plates to the extreme of 700 mm in radius. With a special bending device we have developed, we could bent the stack of silicone plates of 0.5 mm in thick without breaking them and obtained almost similar performance as a pyrolitic graphite monochromator. The enhanced beam divergence created by the strong bent was the source of the intensity gain. Unfortunately we need a low beam divergence, therefore, we loose quite a lot of intensity when we limit the outgoing beam divergence. We are developing a new device to overcome this limitation.

With mfSANS, we have conducted feasibility study using standard samples and steel and other metals with nanoscopic structures in them. As shown in the figure, we successfully measured an intermediate scattering angle region of 0.3-3 nm-1, as well as the low-Q part of 0.07-0.3 nm-1. Note that the sample is under a magnetic field and only the scattering that is parallel to the field is taken.

Although we could obtain reasonable data at the relatively low-Q part, diffuse scattering from the focusing mirror is not negligible and the background due to the scattering is affecting data; we have started to develop a new focusing mirror and now characterizing various mirror materials to improve surface finish.

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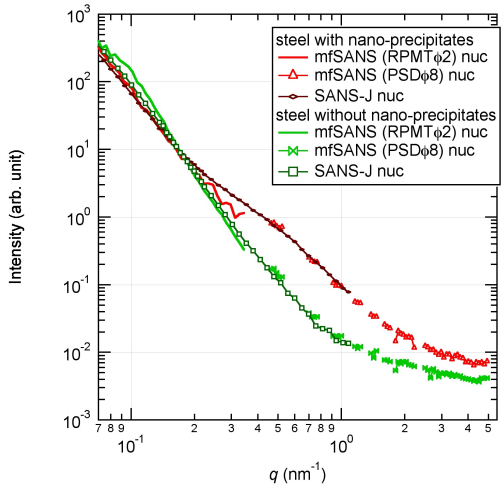

Fig. 1. Small and intermediate-angle neutron scattering in steel with (upper curve) and without (lower curve) nanoscopic precipitates measured by mfSANS and SANS-J.