Development of an X-ray Diffractometer for the Florida Split Coil 25T Magnet

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Introduction

The 25 Tesla Florida Split Coil Magnet, installed in Cell 5 at the NHMFL, allows optical access to a sample via four identical perpendicular beam ports arranged in a cloverleaf fashion. This magnet, in particular, is suitable for in-field X-ray diffraction experiments. The split coil design, however, produces a large magnetic fringe field with the 10 Gauss line at a distance of about 6 meters from the center of the magnet. Therefore, the construction of an X-ray diffractometer requires a number of non-standard approaches as described below.

Experimental Results and Discussion

We used a standard Cu X-ray tube as a source of X-ray radiation. The tube was placed between Helmholtz coils, which compensated the magnet fringe field (Fig.1). It allowed us to install the tube closer to the magnet: at the point where the fringe field was as high as 30 Gauss. The X-ray beam propagated towards the center of the magnet through a beam tunnel made of a 2” diameter stainless steel tube. The tunnel had Be windows at its ends and was mounted on a 2 m long X-95 optical rail to provide extra rigidity and easier alignment on an optical table. Asymmetric installation of the tunnel with respect to the optical window normal allows measurements in larger range of diffraction angles. The tunnel was evacuated to avoid (a) attenuation of the X-rays and (b) ionization of the air. Slits were installed near the magnet end of the tunnel to control the beam cross-section. The inner part of the magnet also was sealed and evacuated. A 1” diameter Be window and a 12” long and 2” high Mylar window were installed on the X-ray input and output ports, respectively. An image plate in a home made holder was used as a detector, due to its insensitivity to magnetic fields. Samples were mounted on a stainless steel probe and loaded through the top end of the magnet bore. The measurements were performed on Si powder at our home laboratory and in the cell (Fig. 2). In the laboratory the detector view area was broad and several diffraction lines were observed. In the cell that view area was limited by the dimensions of the optical ports, windows, and the image plate. For this reason we performed the measurements only in relatively narrow area where the <111> diffraction line was expected to appear. The signal was collected during several hours (Fig. 2).

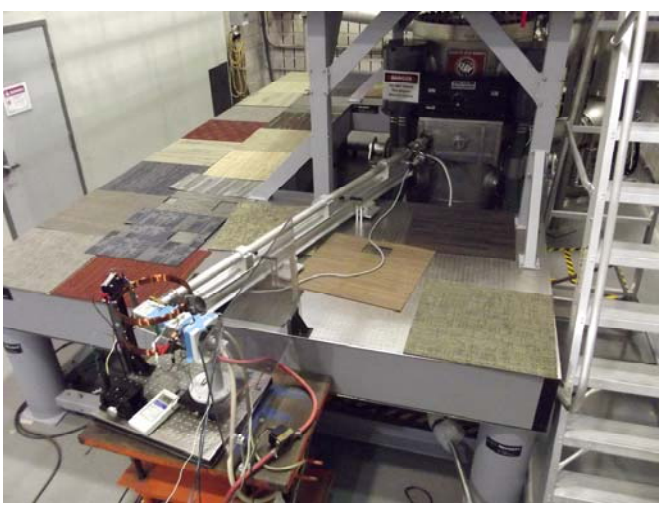

Figure 1. X-ray diffractometer assembled in Cell 5 of the NHMFL DC field facility: the X-ray source side is shown.

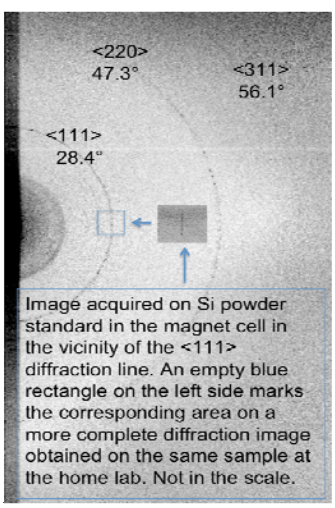

Figure 2. Diffraction images obtained on Si powder in our home laboratory and in the cell.

Conclusions

We designed, built and integrated discrete parts of an X-ray diffractometer, namely X-ray beam tunnel, X-ray windows, image plate holder, and a sample probe with the split coil magnet. We assembled the X-ray diffractometer in the magnet cell and performed initial tests on Si powder standards.

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