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

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Introduction

We designed, built, and tested a proof-of-concept X-ray diffractometer, which is compatible with the 25 T Florida Split Helix Magnet [1], and allows us to make measurements at cryogenic temperatures. This setup provides unique opportunities to perform X-ray diffraction studies in DC magnetic fields in excess of 20 T, thus, positioning NHFML as the only place in the world to perform this kind of studies.

Experimental Results

The diffractometer, which was previously described in Ref. [2], was further developed and improved. Tests were performed on standard samples, specifically Si and LaB_6 powders, to prove reliability of the setup in high magnetic fields. Low temperature measurements were performed in a cryostat designed and built by Janis Research Company, LLC [3] specifically for the magnet. The cryostat allows measurements in the temperature range 15-295 K. Samples were mounted on a cold finger of a homemade probe. The probe was rotated about its axis for sample alignment and θ-2θ measurements, thus implementing a one-axis goniometer configuration. The diffractometer was used to investigate samples of: Terfenol-D [4] (see Fig. 1); Invar [5] ; MP35N alloy; austenitic stainless steels 301; and iron-based superconductor crystal $Fe_{1.12}Te$ (see Fig. 2). Data acquisition from the polycrystalline and powder samples took about one hour, whereas an image from $Fe_{1.12}Te$ crystal was acquired in 15 min with θ rotation over 20° range. Digitizing of the data collected on the image plate took another 45 min.

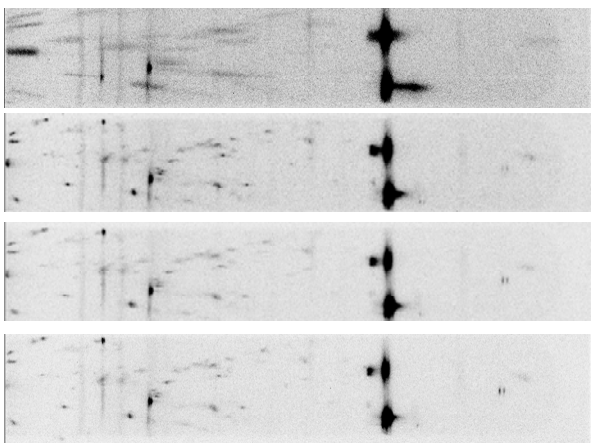

Fig. 1 Evolution of the diffraction image obtained on Terfenol-D at room temperature in magnetic fields of 0, 1, 5, and 10 Tesla (from top to bottom).

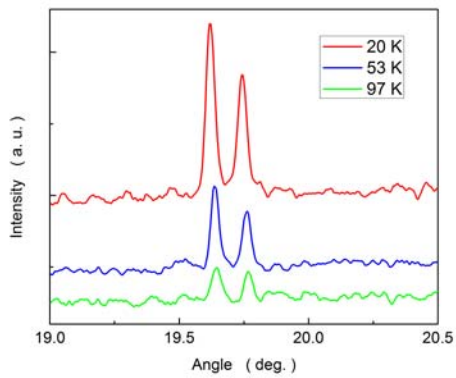

Fig. 2 Intensity of the (003) diffraction peak for $Fe_{1.12}Te$ single crystal in the field of 24 T at various temperatures. The curves are shifted for clarity.

Conclusions

We have shown the feasibility of X-ray diffraction experiments, which, nevertheless, are very time consuming using the image plate detector and a sealed tube source. In its current version the X-ray diffractometer is not yet suitable for detailed investigations of physical phenomena such as phase diagrams, and it is not ready for full deployment in the user program. However, it can be used for simple experiments such as the confirmation of a materials' structural changes that result from variation of temperature and/or magnetic field.

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References

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