

The Design & Construction of a Proton Microprobe Using a GE PETtrace Cyclotron

Michael S. Beumer

Abstract

The interaction of fast neutrons with nuclear materials is a topic of fundamental interest in nuclear engineering. Fast neutrons possess the ability to degrade, and in some cases destroy, materials used in nuclear reactor pressure vessels and core internals. Unfortunately, there are very few facilities where extreme fast neutron fluences, approximately 300 displacements per atom, can be reasonably achieved. Research at the University of Missouri Research Reactor (MURR) Cyclotron has focused on increasing the fast neutron flux density by creating a very tight microspot.

This thesis focuses on characterizing the MURR cyclotron beam through accurate measurements using a radiochromic film technique, originally developed by Avila-Rodriguez.¹ An ion optics system was designed using SIMION, a finite element analysis software.² A quadrupole triplet was used to transport and focus the high-energy beam to a very small point.

A cyclotron-based beamline system was constructed at MURR with the following components: drift tubes, a sample chamber with appropriate vacuum components, and associated instrumentation. An acquisition computer and associated electronics were

remotely positioned, outside of the cyclotron vault, to control the beamline and ion optics. This remote acquisition system includes a program to record beam current, sample chamber pressure, and the current supplied to the quadrupole magnets. Several safety interlocks were designed to protect workers and equipment. The construction, alignment, and startup of the beam line are presented. Preliminary irradiations of graphite with protons are also presented.