Proposal for TRIUMF Commitment (5YP 2015-2020)

Date:
September 17, 2012

PROJECT/COMMITMENT TITLE: Beamline and instruments for studies of implantation, backscattering , diffusion and channeling of 8Li

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PROJECT DESCRIPTION:

The project consists of building a short UHV beamline and chamber with instrument to measure the stopping distribution, backscattering, diffusion, and channeling of 8Li implanted into crystals and other solid media. A 45 degree electrostatic bender would be inserted after the Na cell of the polarizer in ISAC in order to divert the charged 8Li down a new beamline. This must be done is a way which does not affect the neutralized 8Li beam required for betaNMR and fast collinear laser spectroscopy experiments. A second 45 degree bend would bring the beam parallel the existing polarized beam. A short (2m) UHV beamline with differential pumping would guide the beam to a new sample chamber, located just south of the He cell of the polarizer. The new chamber would have multiple capabilities. It should allow samples to be loaded through a load lock onto a sample holder, which is rotatable and temperature controlled over a wide range 20-800K, suitable for diffusion studies. In addition the sample holder can be HV biased from +- 30 kV in order to vary the energy of implantation in the range 0-60 keV. The sample is viewed by a bank of position sensitive Si detectors which measure the energy distribution of alpha particles from 8Li decay as a function of angle with respect to the sample orientation. A Geant4 simulation will be developed to reconstruct the stopping distribution from the Intensity(energy, angle) data sets. It will also be possible measure how the distribution evolves as function of time after a beam pulse and thereby determine the diffusion constant for 8Li in an arbitrary thin film or crystal. **The instrument will also allow measurements of backscattered 8Li off a surface by looking at delayed coincidences with short pulses of 8Li delivered to the sample. The entire setup will be designed to run parasitically to beta-NMR and thus will increase the scientific output with no (additional) beamtime requirements.**

SCIENTIFIC JUSTIFICATION:

The principle probe used in the beta NMR program at ISAC (and soon at ARIEL) is 8Li which decays into 8Be and immediately into two energetic alphas. The 8Li beam is polarized and subsequently implanted into the material of interest. The main science justification is to probe electronic and magnetic properties of thin films and interfaces and a function of depth and to simulate the behaviour of Li in materials. The results depend critically on calculations of the stopping distribution in the energy regions 1-30 keV determined using the TRIM code. However this code is not very reliable at low energies and does not take into account channeling or blocking of the 8Li entering the crystalline samples. Furthermore at low energies a significant fraction the beam is backscattered off the surface and gives rise to an energy dependent background signal. Therefore it is critical for the next stage of beta-NMR that we have a method to reliably measure the stopping distribution and backscattered fraction in the same samples run with beta-NMR. The proposed new instrument is designed for this purpose.

Secondly the 8Li adopts specific crystalline sites that affects the spectra directly through the hyperfine interaction with conduction electrons, the nuclear dipole interaction with neighboring nuclear spins, and the quadrupole interaction from the local electric field gradient. Emission channeling is a powerful way to measure site locations of a

radioactive atom in a crystal as a function of temperature and thus would provide important complementary information to beta-NMR.

Lastly, and perhaps most importantly, the new instrument will allow direct measurements of the diffusion constant of 8Li in thin films, crystals and multilayers. Diffusion of Li is critical to the operation Li batteries. The new instrument will allow direct measurements of Li diffusion in any thin film or crystal as a function of temperature. This would complement the beta NMR measurements which are being done on battery electrode materials. We anticipate these instruments will generate interest from the companies which are developing Li batteries.

RELATIONSHIP TO BROADER CANADIAN RESEARCH COMMUNITY:

BROADER IMPACTS:

MAJOR MILESTONES:

Description	Date
Commision new beamline	2017
Commission instrument	2019

RESOURCE REQUIRMENTS:

CASH FLOW REQUIREMENTS						
\YEAR SOURCE \	ONE	TWO	THREE	FOUR	FIVE	TOTAL
TRIUMF	125K	125K	125K	125K		
EXTERNAL	125K	125K	125K	125K		
TOTAL	250K	250K	250K	250K		
TRIUMF NON-CASH RESOURCES						
\YEAR RESOURCE\	ONE	TWO	THREE	FOUR	FIVE	TOTAL

EXTERNAL FUNDING INFORMATION:

ONGOING OPERATIONAL REQUIREMENTS:

DECOMMISSIONING REQUIREMENT:

Accepted: Date: