Name of CARE facility: Coincidence Doppler Positron Annihilation Radiation System
Location: Nuclear Physics Laboratory
Total cost of equipment/facility: 12 Lakhs
Year of CARE funding: 2003-04 and Operational since, DEC, 2006
Support provided by CARE: 12 Lakhs
Name of Principal Investigator: Prof. H C Verma (hcverma@iitk.ac.in ; Tel: 7681/6610)
Participating departments: PHYSICS, open for all

Brief description and capability of CARE facility:

1. Introduction

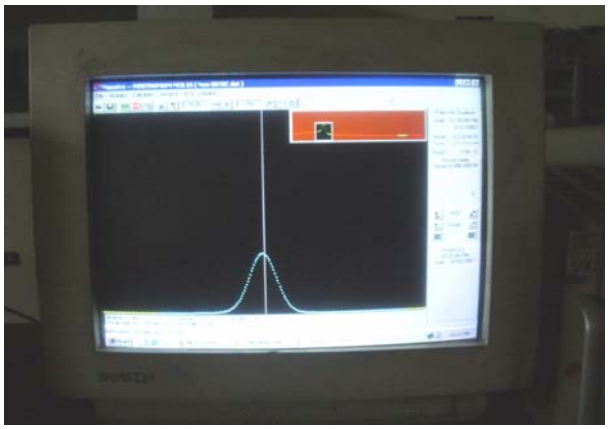
This instrument is meant to study the momentum distribution of electrons in a solid. The basic idea is to send positrons into the sample and look for the energy of the two gamma photons when a positron annihilates with an electron. If the electron-positron system has zero momentum to start with, the two photons come out with exactly equal energy which is very close to 511 keV. The positron readily thermalizes in the solid and so the initial momentum of the electron-positron pair is due to the electron only. This momentum causes a Doppler shift in the gamma ray energy which is measured by a sensitive detector. By analyzing the energy distribution one can draw conclusions about the electron momentum.

The more recent use of this system is to look at the annihilation from the core electrons of the atoms and identify the element which contributes electron for annihilation. This has been useful in looking at elemental surrounding of vacancies and so on.

2. Equipment

The core of the set up is a radio active material ^{22}Na which undergoes beta+ decay with a half life of about 2.5 years, Two high Purity Ge Detectors which can measure gamma ray energies with a resolution of about 1.5 keV, and associated electronics including Data-acquisition

system. The two gamma photons going back to back are detected by the two detectors. The two signal go through a Coincidence circuit and further processing takes place only if they arrive within a small time window, ensuring that we are looking at the genuine 511 keV or so photon coming from the annihilation of positron and not from stray photons generated due to Compton scattering etc.



The energy distribution is obtained using normal electronic modules.

Technical Specifications:
Two detectors: One is DSG and other ORTEC made
Resolution: both have 1.4 keV for the energy 514 keV of ^{85}Sr

Coincidence units and related electronics from ORTEC.

3. Sample requirement

The system can accept solid samples in plate form with linear size about 7mm onwards. Typical thickness should be in the range 1-3 millimeter. Indeed it depends on the nature of sample, the metallic ones need smaller thickness and polymers will need larger thickness.
One can also put the sample in powder form.

4. Typical work

Fe-Al alloys were formed by Arc-melting. The ingots after giving proper homogenization heat treatment were filed to extract powder. The powder sample was subjected to Positron Annihilation Coincidence Doppler Broadening experiments. The quotient spectra for the as cut from the ingot, as filed from the ingot and for the powder annealed for extended time are given below (taken from the Ph D thesis, Preparation of nanophase oxides and iron-based alloys and studies on effect of mechanical deformation on their magnetic and structural properties, IITK 2008)
The following results could be extracted:

a. On filing, a large number of vacancies are created in the powder. Positrons are confined in these and there overlap with core electron diminishes.
b. On filing, some of the Aluminium atoms migrate from their regular B-sublattice to A-sublattice havibg different number of iron, aluminium atoms in the nearest neighbour cell.

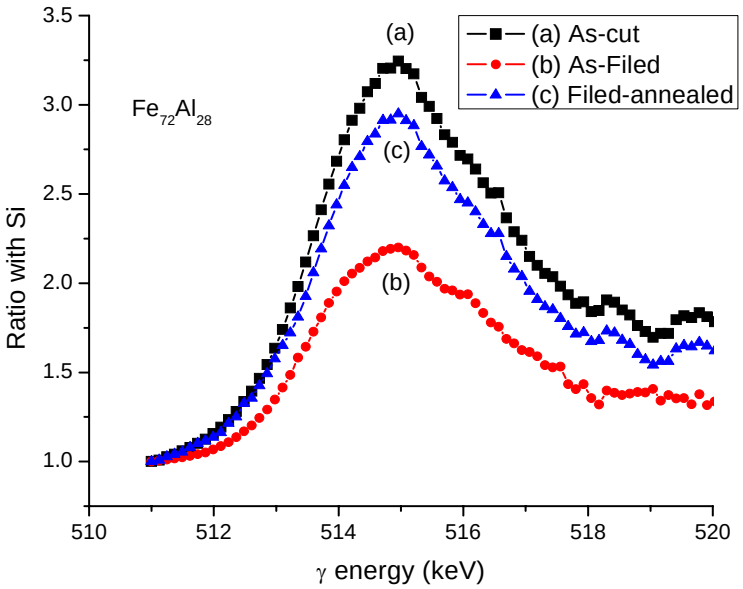


Figure 5.5: Quotient spectra of $Fe_{72}Al_{28}$ alloy

5. Mode of Access

Any one interested in PACDB spectroscopy may contact H C Verma, Dept of Physics.