MAR17-2017-020954

Abstract for an Invited Paper
for the MAR17 Meeting of
the American Physical Society

Role of the Muon in Semiconductor Research

RICK (P.W.) MENGYAN, Northern Michigan University; Texas Tech University

Muons are used in semiconductor research as an experimentally accessible analog to the isolated Hydrogen (H) impurity – a complex that is very difficult (or impossible) to study by other means. Hydrogen impurities of any concentration can modify the electrical, optical or magnetic properties of the host. For instance, H can be incorporated to remove electrically active levels from the energy gap (i.e. passivation) while some can form isolated centers that tend to be responsible for the trap and release of charge carriers and participate in site and charge-state dynamics which certainly affect the electrical properties of the host. Therefore, it can be quite useful to characterize these impurities in semiconducting materials that are of interest for use in devices. A muon has the same charge and spin as a proton but a mass that is nine times lighter. When implanted in a target material, a positively charged muon can behave as a light proton or bind with an electron to form a complex known as Muonium (Mu) with properties that are very similar to that of ionic or neutral H, respectively. A result of these similarities and direct non-destructive implantation is that Mu provides a direct measure of local electronic structure, thermal stability and charge-state transitions of these impurity centers. Since any material can be subjected to muon implantation and it is the muons themselves that mimic the H impurity centers, these measurements do not depend (at all) on the host's solubility of hydrogen nor do they require some minimum concentration; unlike many other techniques, such as EPR, ENDOR, NMR, or IR vibrational spectroscopy. Here we summarize major contributions muons have made to the field of semiconductor research followed by a few case studies to demonstrate the technique and detailed knowledge of the physical and electronic structures as well as dynamics (e.g.: charge-state and site transitions; local motion; long-range diffusion) of Mu/H that can be obtained.