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Effect of oxygen ion irradiation on dielectric, structural, chemical and thermoluminescence properties of natural muscovite mica

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ABSTRACT

Thin cleaved samples (~18 µm) of natural muscovite mica were irradiated with 80 MeV oxygen ion beam at fluence ranging from 1×10^{12} to 5×10^{13} ion/cm^2. The alterations in dielectric, structural, chemical and thermoluminescence properties of irradiated as well as pristine samples have been investigated. Dielectric constant decreases while other dielectric parameters such as dielectric loss, tanδ, ac conductivity, real and imaginary parts of electric modulus increase with increase of ion fluence. Williamson Hall investigation has been utilized to ascertain crystallite size and micro strain of pristine and irradiated samples. The XRD analysis revealed a significant increase in micro strain and dislocation density with an increase of ion fluence. The variations in dielectric properties upon irradiation are collaborated with structural modifications in the muscovite. No appreciable changes in characteristic bands (FTIR) have been observed after irradiation, indicating that natural muscovite mica is chemically stable. Natural muscovite mica has eminent applications in heavy ions dosimetry due to observation of well defined single peak at 303 °C with activation energy of 1.24 eV in TL spectrum.

1. Introduction

In recent years, Swift heavy ion (SHI) induced alteration in polymers, glasses and minerals were being studied in respect of their structural, optical, chemical and dielectric properties to promote their use for the development of insulating systems and dosimeter in radiation rich environment (Kumar et al., 2012a, 2012b; Kaur et al., 2013a). Natural Muscovite mica is structurally significant because it has a layered structure comprising of aluminium silicate sheets weekly bonded together by layers of potassium ions. These potassium ion layers create the perfect cleavage of muscovite. Muscovite mica is one of the most common insulators being used in power electronics capacitors because it exhibits outstanding insulation properties, combined with good mechanical and thermal properties (Blaise et al., 2009). It is a highly reliable material exhibiting low ionizing radiation-induced conductivity and resistant to electrical micro discharges that cause instabilities in electronic circuits and are precursors of electrical breakdown (Blaise et al., 2009).

Heavy ion irradiation of muscovite mica is a subject of scientific interest from last two decades, especially the formation of tracks and morphological studies (Dartyge and Sigmund, 1985; Thibaudau et al., 1991; Wang et al., 1998; Singh et al., 2010; Wang et al., 2012; Mo et al., 2012). Ionizing radiations passing through matter, deposit energy in the material and produces considerable changes in the microstructure of that material which in turn changes its structural, dielectric and optical properties (Singh, 1999). So it is necessary to identify the modifications due to irradiation of muscovite mica with regard to their dielectric, structural, chemical and thermoluminescence properties.

A significant amount of work has been done on the dielectric (Chaudhry et al., 1985; Chaudhry and Jonscher, 1985; Bano and Jonscher, 1992; Dawy, 2002), structural and chemical (Shishelova et al., 1974; Orlova et al., 1974) properties of natural muscovite mica without irradiation. However no study has been accounted so far to explore the impact of heavy ion irradiation on the dielectric, structural and chemical properties of muscovite mica. Therefore, in the present work, the effect of oxygen ion irradiation on dielectric, structural, optical and chemical properties of muscovite mica have been examined to utilize this material for innovative applications in radiation technology and opto-electronic devices.

Thermo luminescence (TL) is a crucial phenomenon that takes place in various irradiated natural minerals (Kaur et al., 2013c, 2014a, 2014b). TL studies of the minerals have been used to examine their potential for TL dosimetry and dating. It was well known that TL properties of minerals which mined from different geographical locations are different. It is also comprehended that the contents of the impurities in minerals play an essential role in TL properties. Generally

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