

RAMAN STUDIES OF COPPER INDIUM TELLURIDE, COPPER GALLIUM TELLURIDE AND COPPER INDIUM GALLIUM TELLURIDE

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ABSTRACT:

Copper indium Telluride Copper Gallium Telluride Copper indium Gallium Telluride films were deposited for the first time by the pulse electro- deposition technique at room temperature and at a constant potential of – 0.75 V(SCE)[1,2,3]. The films exhibited single phase. Optical band gap of the films were determined for various duty cycles. Capacitance voltage measurements indicated the films to exhibit p-type behavior. Resistivity was calculated from the resistance values and it was observed that the resistivity increases [4] with increase of indium content. Now in this research article raman studies of CIT, CGT and CIGT films were studied.

Keywords: Thin films, Solar cells, Pulse electrodeposits, I–III–VI₂ semiconductors, and chalcopyrite, Raman Spectrum, Vibrational spectroscopy

1. INTRODUCTION

Raman spectroscopy is a form of vibrational spectroscopy, much like infrared (IR) spectroscopy. However, IR bands arise from a change in the dipole moment of a molecule whereas Raman bands arise from a change in the polarizability. In many cases, transitions that are allowed in Raman are forbidden in IR, and hence the techniques are often complementary. This note briefly explains the Raman Effect, some advantages of Raman spectroscopy, and the basics of Raman instrumentation.

When a beam of light is impinged upon a sample, photons are absorbed by the material and scattered. The vast majority of these scattered photons has exactly the same wavelength as the incident photons and is known as Rayleigh scatter, but a tiny portion (approximately 1 in 10⁷) of the scattered radiation is shifted to a different wavelength. These wavelength shifted photons are called Raman scatter. Most of the Raman scattered photons are shifted to longer wavelengths (Stokes shift), but a small portion are shifted to shorter wavelengths (anti-Stokes shift). In Rayleigh scattering the electron decays back to the same level from which it started. In both types of Raman scattering the electron decays to a different level than that where it started. Stokes Raman scattering

occurs when the final energy level is higher than the initial level, while anti-Stokes Raman scattering occurs when the final energy level is lower than the starting level. Stokes scattering is much more common than anti-

Stokes scattering because at any given time an electron in the most common temperature range is most likely to be in its lowest energy state, in accordance with the Boltzmann distribution. Only Stokes Raman scattering is commonly used in spectroscopy. As mentioned above, Raman is a form of vibrational spectroscopy. This means that these energy transitions arise from molecular vibrations. Since these vibrations involve identifiable functional groups, when the energies of these transitions are plotted as a spectrum, they can be used to identify the molecule.

A Raman spectrum is a plot of the intensity of Raman scattered radiation as a function of its frequency difference from the incident radiation (usually in units of wavenumber, cm⁻¹). This difference is called the Raman shift, and since it is a difference value, the Raman shift is independent of the frequency of the incident radiation. Typically, only the Stokes region is used where as the anti-Stokes spectrum is identical in pattern, but much less intense. Raman spectroscopy is useful for chemical analysis for several reasons: it exhibits high specificity, it is compatible with aqueous systems, no special preparation of the sample is needed, and the timescale of the experiment is short.

Since Raman lines are of fundamental vibrations, Raman bands have a good signal-to-noise ratio and are non-overlapping. This allows a Raman spectrum to be used for everything from fingerprinting, of samples to constructing complex chemical models of reaction processes.

The IR spectrum of water is strong and relatively complex, making IR inadequate for analysis of aqueous solutions due to heavy interference by the water bands. However, the Raman spectrum of water is weak and unobtrusive, allowing good spectra to be acquired of species in aqueous solution.

Unlike most other chemical analysis techniques, Raman requires no special preparation of the sample. In fact, no contact with the sample is needed at all because Raman involves only illuminating a sample with a laser and collecting the scattered photons. Hence the technique makes Raman spectroscopy non-destructive.

Because a Raman spectrum can be acquired in as little as a few seconds, Raman can be used to monitor chemical reactions in real time.

A typical Raman spectrometer is made up of three basic parts: the laser, the collection device, and the spectrograph.

A laser is used to excite Raman spectra because it gives a coherent beam of monochromatic light. This gives sufficient intensity to produce a useful amount of Raman scatter and allows for clean spectra, free of extraneous bands. Lasers used for Raman spectroscopy must exhibit good wavelength stability and low background emission.

2. EXPERIMENTAL

The probe is a collection device that collects the scattered photons, filters out the Rayleigh scatter and any background signal from the fiber optic cables, and sends the Raman scatter to the spectrograph. Many probes also focus and deliver the incident laser beam.

When Raman scattered photons enter the spectrograph, they are passed through a transmission grating film (CIT, CGT, CIGT) to separate them by wavelength and passed to a detector, which records the intensity of the Raman signal at each wavelength. This data is plotted as the Raman spectrum.

RESULTS:

Fig.1 shows the Raman spectra of CuInTe₂ films deposited at different duty cycles. Three lines at 125, 170 and 220 cm⁻¹ are observed in the spectra. The width of the lines is observed to decrease with increase of duty cycle, due to the increase of grain size with duty cycle. The high symmetry, non-polar A₁ mode is observed at 125 cm⁻¹. This is the highest intensity mode observed in the chalcopyrite compounds and arises due to the motion of anions alone with cations at rest. In the present case, it is purely due to tellurium motion without involving Cu or In. As a result, the value of A₁ is not expected to differ much for the telluride's [22]. The second peak in the spectrum observed at 170 cm⁻¹ corresponds to the E⁵ mode and/ or B₂³ (TO) mode [23]. The peak observed at 220 cm⁻¹ can be assigned to the E₆ (LO) mode [24].

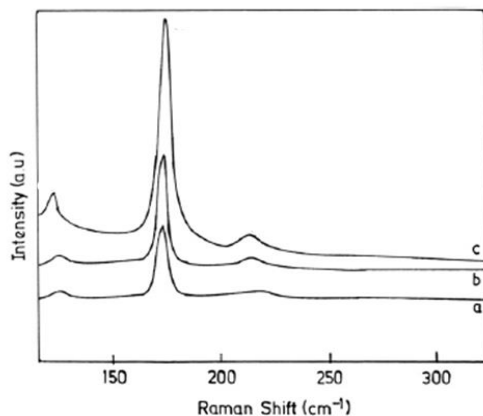


Fig 1

Fig. 2 shows the Raman spectra of CGT films deposited at different duty cycles. It can be observed that A₁ mode shifts to higher frequencies with increase of duty cycle. The width of the peak also decreases as the duty cycle increases.

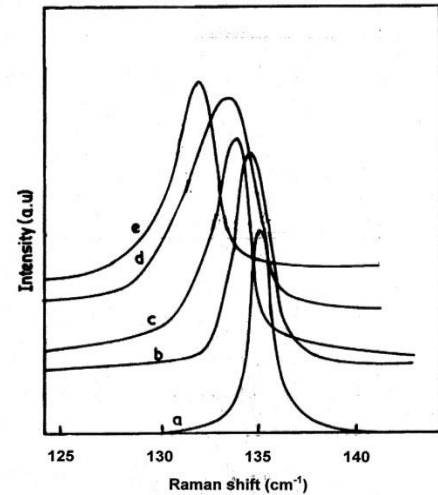


Fig 2

Fig. 3 to fig. 7 show the Raman spectra of CGT films deposited at different duty cycles. It can be observed that A₁ modes of CIT and CGT are observed at 125 cm⁻¹ and 135 cm⁻¹, the A₁ mode at 125 cm⁻¹ shifts towards CGT as the concentration of Ga increases and the peak at 135 cm⁻¹ shifts to higher frequencies with increase of Ga concentration.

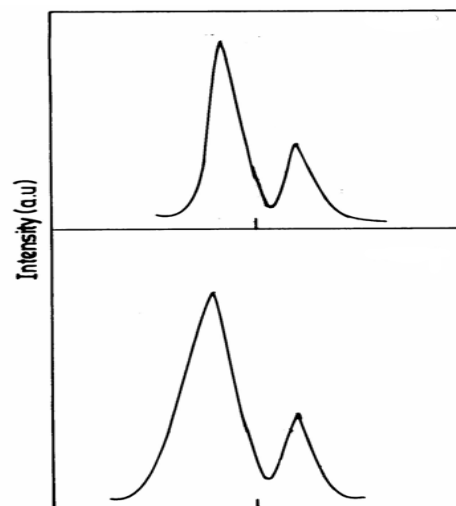


Fig 3

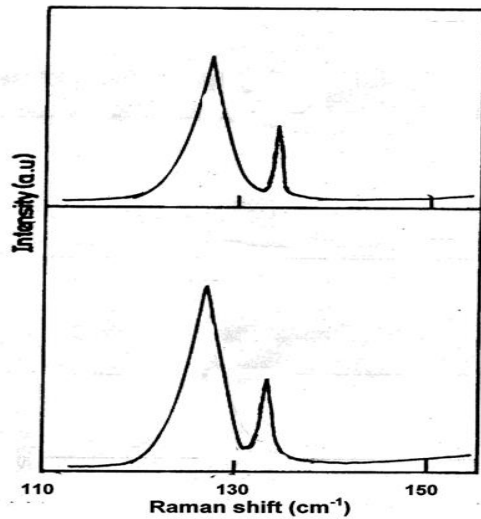


Fig 4

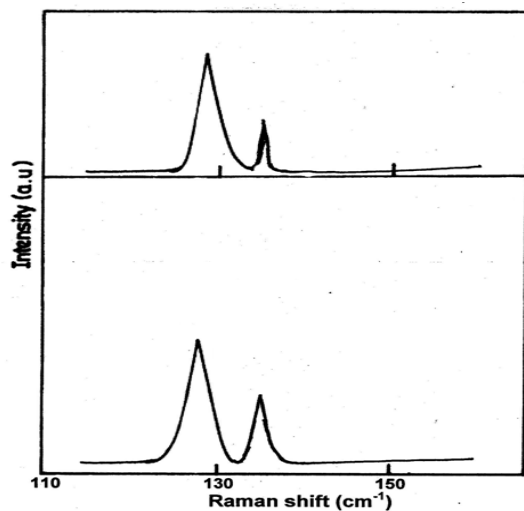


Fig 5

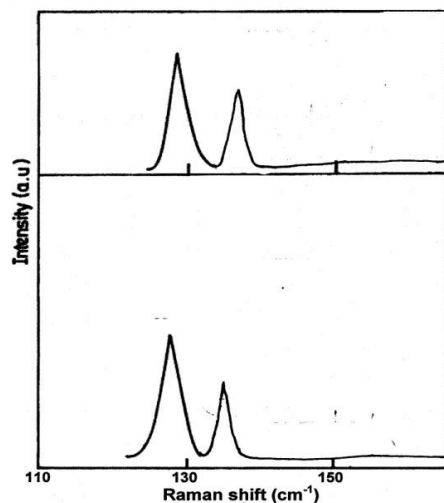


Fig 6

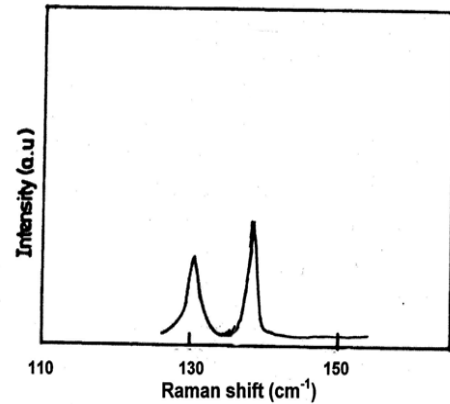


Fig 7

Laser Raman studies indicated strong peaks at 125 cm^{-1} and 138 cm^{-1} . These peaks shifted with increase of gallium content.

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