Introduction: Silicon (Si) is the most abundant semiconductor-material found in form of silica (SiO₂) contributing in the fields of macro to microelectronics. In particular, nanocrystalline Si (nc-Si) is promising for future optoelectronics, as it shows material properties of both amorphous-Si and polycrystalline-Si. Current methods of obtaining nc-Si involve re-crystallization of amorphous-Si, or direct deposition of nc-Si through chemical vapor deposition (CVD). Various complex-steps, requirement of high-temperature, toxic materials in the current techniques limit its potential applications. In this study, we have focused on a simple method for the formation nc-Si films on insulator-type substrates (i.e., silica: glass or quartz etc) through aluminothermic reduction of the substrates. According to thermodynamic properties of SiO₂, aluminothermic reduction occurs around melting point of aluminum (Al), (~ 650°C) following the basic equations:

\[ \text{SiO}_2 \text{(Solid)} + 4e^- \rightarrow \text{Si (reduced)} + 2O^2- \]  

(1)

\[ \text{Al (s)} \rightarrow \text{Al}^{3+} + 3e^- \]  

(2)

\[ 3\text{SiO}_2\text{(S)} + 4\text{Al (S)} = 3\text{Si (s)} + 2\text{Al}_2\text{O}_3\text{(s)} \]  

(3)

Experimental: Al thin-films with thickness of ~ 100 nm were deposited through thermal evaporation of Al on quartz or borosilicate glass-substrates. Then, Al/quartz (or glass) structure was transferred to a thermal annealing system, where it was annealed at 700°C in the vacuum; thereby, going through aluminothermic reduction, where surface of the silica-substrate reduced to become Si-film. Si-films were characterized by Raman spectroscopy, photoluminescence, scanning electron microscopy (SEM), and optical measurement etc.

Results and Discussions:

Fig.1 (a) Raman spectra of aluminothermic reduced Si-film on quartz-substrate; (b) Band-gap determination from data obtained by UV-visible measurement

Results and Discussions: Shown in Fig. 1(a) are the Raman spectra of Si thin-films obtained through aluminothermic reduction of a borosilicate glass and a quartz-substrates, performed at 700°C with 1-hour of reaction time (annealing). Raman spectrum of the oriented single-crystal Si-wafer has been shown as a reference. A broadened asymmetric peak at ~514 cm⁻¹ has been apparent for Si-films on both the glass and the quartz-substrate. A large shift of peak at 514 cm⁻¹ comparing to the peak of Si-wafer at ~ 520 cm⁻¹ roughly suggests formation of nc-Si through aluminothermic reduction of the surface of SiO₂-substrates. Optical band-gap (E₂), of the nc-Si films obtained by absorption measurement was found around 2.5 eV (Fig. 1 (b)), which is characteristic for the nc-Si thin-films. Annealing time was varied during reduction to study the effect of reaction time on the quality of the nc-Si films. Optical and structural properties were discussed in relation to the various annealing time.