

# DETERMINE THE SIZE OF SI QUANTUM DOTS BY RAMAN METHOD

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Thermal evaporation grown Si nanoparticles were studied by Raman method. Thermal evaporation method [1] can prepare the strainless and spherical quantum dots. The size of grown quantum dots can be controlled through the adjusting Ar gas pressure in the growth chamber. In this study, Si nanoparticles were grown on two different substrates, 7059 glass and sapphire. The Raman lineshape of these grown Si nanoparticles are broadened and accompanied with the redshift. As point out by H. Richter *et. al.*[2], the Raman profile are deeply influenced by the size of dot.

As the size of polycrystalline is smaller than 300 Å, the profile of Raman intensity is given by the equation suggested by Richter [2] and developed by Campbell [3], that is

$$I(\omega) = \int_0^1 d^3q \frac{\exp\left(-q^2 d^2 / 4\right)}{[\omega - \omega(q)]^2 + (\Gamma/2)^2} \quad (1)$$

where  $q$  is the wave number in unit of  $2\pi/a_0$  ( $a_0 = 0.357$  nm being the lattice constant of Si).  $d$  is the average size of the quantum dots in unit of  $a_0$ , and  $\Gamma$  is the FWHM of the phonon peak.  $\omega(q)$  is the dispersion curve of Si, which can be approximately equal to

$$\omega(q) = [A + B \cos(\pi q/2)]^{1/2} \quad (2)$$

with  $A = 1.714 \times 10^5 \text{ cm}^{-2}$  and  $B = 1.000 \times 10^5 \text{ cm}^{-2}$ .

The optical phonon of Si dots is fit with equation (1) after the signal from substrate was eliminated. A typical fitting result is shown in Fig. 1. We found that the average size of growth Si quantum dots has a linear relation with the Ar gas pressure less than 2 torr. Above 2 torr, the average size of growth Si quantum dots reached a maximum size about 9 nm, as indicated in Fig.2 (a) and (b). The average diameter of the thermal-evaporation-grown Si dots determined by the TEM images is comparable with the Raman result.

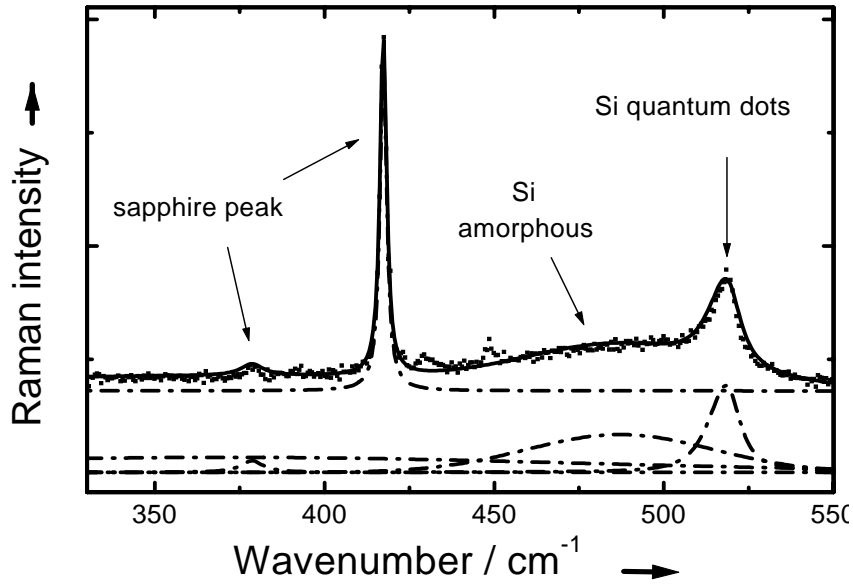


Fig. 1 Raman spectrum of growth Si quantum dots on sapphire with 2.0 torr Ar gas pressure fit by equation (1). The Raman signal from substrate is eliminated.

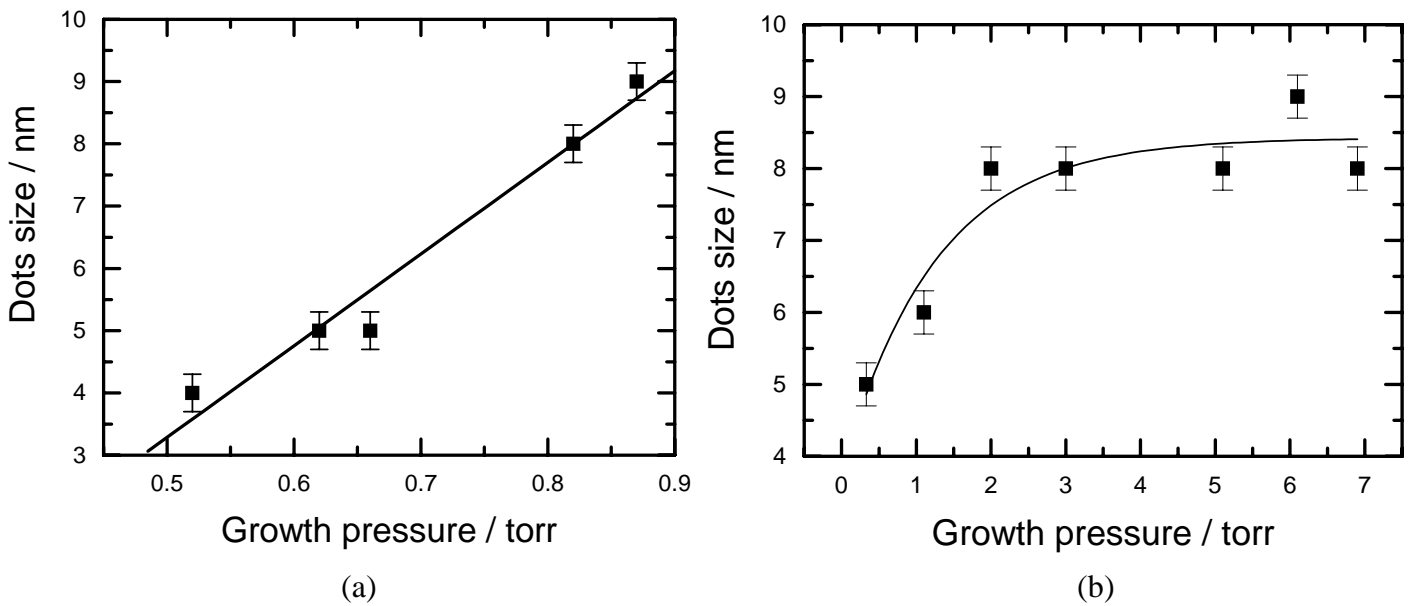


Fig. 2 Result from fitting, the average size of growth Si quantum dots is proportional to the Ar gas pressure when the pressure lower than 2 torr; and reached a maximum average size about 9 nm after 2 torr.

1. Yu-Cheng Liao, Shih-Yen Lin, Si-Shen Lee and Chih-Ta Chia, *Appl. Phys. Lett.* **77**, 4328 (2000).
2. H. Richter, Z. P. Wang and L. Ley, *Solid State Commun.* **39**, 625(1981).
3. I. H. Campbell and P. M. Fauchet, *Solid State Commun.* **58**, 739(1986).