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# Effect of crystallinity on optical, electrical and photovoltaic properties of silicon nanoparticles synthesized by non-thermal plasma

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## 1. Introduction

Silicon nanocrystal is becoming an attractive topic after the pioneer work of Canham on luminescent porous silicon[1]. Silicon nanocrystals have great advantages such as abundant, non-toxicity, and size-dependent optical and electrical properties[2, 3]. This makes it very promise in optoelectric and biomedical applications, including light emitting diodes, photodetectors, solar cells, bio-imaging, and so on[4]. Comparing to complicated liquid-synthesis, convenient and mass production of free standing silicon nanoparticles can be realized by using non-thermal plasma. Particle size, crystallinity can be well controlled independently by changing parameters.[2-5] In this work, the influence of particle crystallinity on its optical, electrical and photovoltaic properties has been studied systemically.

## 2. Experiment & Results

A quartz tube with inner diameter of 45 mm was employed as the reactor. Very high frequency (VHF) at 70 MHz was supplied on two copper electrodes surrounding on quartz tube. All silicon nanoparticles were synthesized with 8 standard cubic centimeters per minute ($cm^3$/min) of silicon tetrachloride ($SiCl_4$), 80 $cm^3$/min of $H_2$, and 240 $cm^3$/min of Ar at a pressure of 400 Pa with different applied power of 30, 50 and 65 W, respectively. Nanoparticles synthesized in the plasma were collected downstream of the plasma on a stainless mesh. All of the synthesis and handling of nanoparticles were conducted without exposure to air unless otherwise noted.

Raman spectra of particles synthesized at different power are shown in Figure 1; broad peak around 480 $cm^{-1}$ is related to amorphous phase while sharp peak at 520 $cm^{-1}$ is attributed to crystal phase. An obvious peak around 480 $cm^{-1}$ can be detected from particles synthesized at 30 W, indicating most of particles are amorphous. Particle crystallinity increases with applied power, and particles synthesized at 65 W are almost all crystallized.

Carrier mobility of different particles are obtained by making thin film transistor with structure as illustrated in Figure 2. In addition, silicon nanoparticle and conjugated hybrid solar cells were also fabricated as shown in Figure 3. Detailed device performance with different particles will be presented on conference.

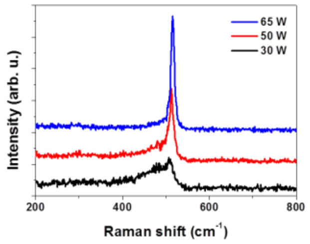


Figure 1. Raman spectra of silicon nanoparticles synthesized at different power.

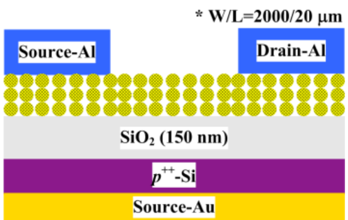


Figure 2. Schematic diagram of silicon nanoparticle transistor.

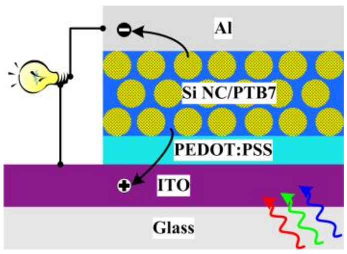


Figure 3. Schematic diagram of hybrid solar cell.

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