Single-crystal $\beta$-SiC nanowires coated with amorphous SiO$_2$ were synthesized by a simple thermal evaporation technique. The photocatalytic activity of the SiC nanowires was characterized by measuring the photodegradation rate of acetaldehyde catalyzed by SiC as a function of UV irradiation time. It exhibited excellent photocatalytic activity, leading to the efficient decomposition of acetaldehyde by irradiation with UV light. The progress of the photocatalytic reaction can be monitored by the evolution of one of the products, CO$_2$. It has been observed that the as-synthesized SiC nanowires (with the SiO$_2$ coating) have higher catalytic activity than the HF-etched, oxide-free SiC nanowires. © 2006 American Institute of Physics. [DOI: 10.1063/1.2219139]
The absorption coefficient $\alpha$ for SiC nanowire solution was determined as a function of the photon energy $h\nu$ (Fig. 3). The absorption coefficient $\alpha$ can be expressed as:

$$\alpha = \frac{1}{T} \cdot \frac{1}{\chi} \cdot \frac{1}{d},$$

where $T$ is transmittance, $\chi$ is the effective thickness of the sample, and $d$ is the thickness of the sample. It is known that the relationship between the absorption coefficient $\alpha$ near the absorption edge and the optical band gap $E_g$ for indirect interband transitions follows

$$\alpha^{1/2} = A^* (h\nu - E_g)^{1/2},$$

where $A^*$ is constant, $h\nu$ is the photoenergy, $h$ is the Planck constant ($6.63 \times 10^{-34}$ J s), $\nu$ is the frequency of the incident light, and $E_g$ is the optical band gap of the semiconductor. The band gap energies were determined by extrapolating of the linear part of curves to zero.

The photocatalytic activity of the SiC nanowires was evaluated by measuring the photodegradation rates of CH$_3$CHO for SiC in a quartz vessel as a function of UV irradiation time under UV light (1.5 mW cm$^{-2}$). The photodegradation rate is calculated by the following equation:

$$\text{photodegradation rate} = \frac{(C_0 - C)/C_0 \times 100\%}{t},$$

where $C_0$ is initial concentration of gaseous acetaldehyde (CH$_3$CHO) and $C$ is the CH$_3$CHO concentration at time $t$. From Fig. 4(a), we observed that the photodegradation rate of CH$_3$CHO increases monotonically with the extension of irradiation time $t$. Plots of ln($[C_0 - C]/C$) vs. $t$ for each run fit a straight line, which indicates that CH$_3$CHO decomposition is a first order reaction.

It was found from Fig. 4(a) that the increase of the initial gaseous acetaldehyde concentration leads to a strengthened conversion of gaseous acetaldehyde. This is attributed to the larger amount of those gaseous acetaldehyde molecules attached to the surface of the SiC nanowire powders. After 6 h,
the photodegradation of SiC to initial 100 ppm of gaseous acetaldehyde is 54.99%, increased by 12% for the initial 50 ppm of gaseous acetaldehyde. These results shown in Fig. 4(b) are also corroborated by the concentration variation of produced CO₂, evolved as result of photodecomposition of acetaldehyde, as a function of irradiation time. The CO₂ concentration increases with the photodegradation rate of gaseous acetaldehyde. That is to say, the acetaldehyde is converted into CO₂. However, the CO₂ concentration increase is not linear because of the appearance of intermediate compound during the conversion process. In the subsequent reactions, it is generally agreed that the formed acetic acid is the intermediate compound from the conversion of acetaldehyde by photocatalysis in gaseous phase. Moreover, the enhanced photocatalytic activity of SiC nanowires is attributed to the generation of the strong oxidant OH radical.\(^3\)

\[ \text{SiC} + h\nu \rightarrow e^- (\text{electron}) + h^+ (\text{hole}), \]  
\[ \text{H}_2\text{O} \rightarrow \text{H}^+ + \text{OH}^-, \]  
\[ \text{h}^+ + \text{OH}^- \rightarrow \text{OH}_2, \]  
\[ \text{H}_2\text{O} + \text{h}^+ \rightarrow \text{H}^+ + \text{OH}^-, \]  
\[ \text{CH}_3\text{CO} + \text{H}_2\text{O} + 2\text{h}^+ \rightarrow \text{CH}_3\text{COOH} + 2\text{H}^+, \]  
\[ \text{CH}_3\text{COOH} + 2\text{h}^+ + 2\text{OH}^- \rightarrow 2\text{CO}_2 + 2\text{H}^+. \]

To investigate the effect of the SiO₂ coating on the SiC nanowires, the 5% HF etched SiC nanowires (remove off the coated SiO₂ layer completely) were also studied under the same conditions. As can be seen from Fig. 4, the synthesized SiC nanowires have higher photocatalytic activity than the HF-treated SiC nanowires. The enhanced photocatalytic activity of synthesized SiC nanowires can be explained by the enhanced absorption of gaseous acetaldehyde on the SiC nanowires over the HF-treated SiC nanowires, or by the high probability of trapping of an excited electron in the conductive band of SiC. The process leads to more efficient and longer charge separation by minimizing the electron-hole recombination. Nanosized SiO₂ was rich in massive superficial hydroxyl radicals (–OH), which can form activate hydroxyl radicals (OH⁻) according to a reaction with excited electronic and hole. In addition, based on the consumption of lattice oxygen atoms for the “related” TiO₂ system proposed by Thompson et al., the SiO₂ layer is probably responsible for the enhanced catalytic activity for acetaldehyde because it may be a significant source of oxygen for the oxidation of acetaldehyde.

In conclusion, large-scale β-SiC nanowires coated with a trace of amorphous silicon oxide layer were synthesized by high-frequency induction heating of SiO powders. Typically a single nanowire has an average core of 8–20 nm in diameter. The optical band gap was evaluated to be about 2.5 eV, which indicates a slight blueshift from the bulk SiC. The photocatalytic activity of the obtained β-SiC nanowires was evaluated by the photocatalytic decomposition of gaseous acetaldehyde accompanied by the generation of CO₂. The result shows that the β-SiC nanowire exhibits the characteristic of an excellent photocatalyst. Furthermore, it is found that the as-synthesized amorphous SiO₂ coated SiC mani-

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