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(54) **NANOWIRE SYNTHESIS FROM VAPOR AND SOLID SOURCES**

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(58) **Field of Classification Search** None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

7,297,446 B2 11/2007 Fukui et al.
7,335,259 B2 2/2008 Hanrath et al.

2006/0046480 A1* 3/2006 Guo 438/685
2007/0105356 A1* 5/2007 Wu et al. 438/584
2008/0261112 A1* 10/2008 Nagata et al. 429/218.1
2009/0042102 A1 2/2009 Yi et al.
2009/0176159 A1 7/2009 Aruna et al.

FOREIGN PATENT DOCUMENTS

WO 2005119753 A2 12/2005

OTHER PUBLICATIONS

Chang, J.B., et al.; "Ultrafast growth of single-crystalline Si nanowired", Materials Letters, 2006, 2125-2128 pps., vol. 60, Elsevier.

Lee, Kun-Hong, Ph.D., "Synthesis of Si nanowires for an anode material of Li batteries", Defense Technical Information Center Report; Jun. 28, 2006-Nov. 1, 2007, 30 pages, South Korea.

(Continued)

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(57) **ABSTRACT**

Methods of the present invention can be used to synthesize nanowires with controllable compositions and/or with multiple elements. The methods can include coating solid powder granules, which comprise a first element, with a catalyst. The catalyst and the first element should form when heated a liquid, mixed phase having a eutectic or peritectic point. The granules, which have been coated with the catalyst, can then be heated to a temperature greater than or equal to the eutectic or peritectic point. During heating, a vapor source comprising the second element is introduced. The vapor source chemically interacts with the liquid, mixed phase to consume the first element and to induce condensation of a product that comprises the first and second elements in the form of a nanowire.

11 Claims, 4 Drawing Sheets

