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(54) **METHODS OF FABRICATING GALLIUM NITRIDE SEMICONDUCTOR LAYERS ON SUBSTRATES INCLUDING NON-GALLIUM NITRIDE POSTS**

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(56) **References Cited**

**U.S. PATENT DOCUMENTS**

4,127,792 A 11/1978 Nakata ..... 313/500  
4,522,661 A 6/1985 Morrison et al. .... 148/33.2

(List continued on next page.)

**FOREIGN PATENT DOCUMENTS**

CA 2258080 10/1998  
EP 0 551 721 A2 7/1993

(List continued on next page.)

**OTHER PUBLICATIONS**

Honda et al., Selective Area Growth of GaN Microstructures on Patterned (111) and (001) Si Substrates, 4<sup>th</sup> European Workshop on GaN, Nottingham, UK, Jul. 2-5, 2000.

Gehrke et al., Pendeo-Epitaxial Growth of Gallium Nitride on Silicon Substrates, Journal of Electronic Materials, vol. 29, No. 3, Mar. 2000, pp. 306-310.

(List continued on next page.)

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(57) **ABSTRACT**

A substrate includes non-gallium nitride posts that define trenches therebetween, wherein the non-gallium nitride posts include non-gallium nitride sidewalls and non-gallium nitride tops and the trenches include non-gallium floors. Gallium nitride is grown on the non-gallium nitride posts, including on the non-gallium nitride tops. Preferably, gallium nitride pyramids are grown on the non-gallium nitride tops and gallium nitride then is grown on the gallium nitride pyramids. The gallium nitride pyramids preferably are grown at a first temperature and the gallium nitride preferably is grown on the pyramids at a second temperature that is higher than the first temperature. The first temperature preferably is about 1000° C. or less and the second temperature preferably is about 1100° C. or more. However, other than temperature, the same processing conditions preferably are used for both growth steps. The grown gallium nitride on the pyramids preferably coalesces to form a continuous gallium nitride layer. Accordingly, gallium nitride may be grown without the need to form masks during the gallium nitride growth process. Moreover, the gallium nitride growth may be performed using the same processing conditions other than temperatures changes. Accordingly, uninterrupted gallium nitride growth may be performed.

**18 Claims, 2 Drawing Sheets**

