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**Niimi et al.**

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(54) **TEMPERATURE SPIKE FOR UNIFORM NITRIDIZATION OF ULTRA-THIN SILICON DIOXIDE LAYERS IN TRANSISTOR GATES**

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(57) **ABSTRACT**

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An embodiment of the present invention is a method of forming an ultra-thin dielectric layer, the method comprising the steps of: providing a substrate having a semiconductor surface; forming an oxygen-containing layer on the semiconductor surface; exposing the oxygen-containing layer to a nitrogen-containing plasma to create a uniform nitrogen distribution throughout the oxygen-containing layer; and re-oxidizing and annealing the layer to stabilize the nitrogen distribution, heal plasma-induced damage, and reduce interfacial defect density.

(\*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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This annealing step is selected from a group of four re-oxidizing techniques:

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Consecutive annealing in a mixture of H<sub>2</sub> and N<sub>2</sub> (preferably less than 20% H<sub>2</sub>), and then a mixture of O<sub>2</sub> and N<sub>2</sub> (preferably less than 20% O<sub>2</sub>);

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annealing by a spike-like temperature rise (preferably less than 1 s at 1000 to 1150° C.) in nitrogen-comprising atmosphere (preferably N<sub>2</sub>/O<sub>2</sub> or N<sub>2</sub>O/H<sub>2</sub>);

(58) **Field of Search** ..... **438/775, 776, 438/777, 513, 791, 792**

annealing by rapid thermal heating in ammonia of reduced pressure (preferably at 600 to 1000° C. for 5 to 60 s);

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

annealing in an oxidizer/hydrogen mixture (preferably N<sub>2</sub>O with 1% H<sub>2</sub>) for 5 to 60 s at 800 to 1050° C.

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**13 Claims, 5 Drawing Sheets**

