

Claims

1. A sputter deposition system including a vacuum chamber containing a sputtering plasma therein for sputter depositing a layer of material into substrate contacts having very small dimensions, the sputter deposition system comprising:

a target of deposition material positioned in the vacuum chamber and coupled to a target bias source for negatively biasing the target such that ions from the sputtering plasma bombard the target and produce material particles to deposit on a surface of a substrate in the chamber and into the substrate contacts;

a collimator positioned opposite the target and configured to intercept sputtered particles of a predetermined angular incidence to the substrate surface to promote uniform deposition into the substrate contacts;

an electrical biasing system operably coupled to the substrate during sputter deposition, the biasing system ^{including one of an AC source and a pulsed DC source} ~~operable to~~ ^{for biasing the substrate} ~~bias the substrate~~ such that ions from the sputtering plasma bombard the substrate surface and effectively etch the surface generally contemporaneously with the sputter deposition and redistribute the deposited particles in the contacts to reduce

deposition overhang in the contacts and to further promote uniform deposition into the contacts;

whereby substrate contacts having large aspect ratios may be uniformly coated with a layer of material and filled with material with reduced numbers of voids.

2. The sputter deposition system of claim 1 wherein the collimator is operably coupled to the substrate biasing system and the target bias source and acts as a common reference potential to both the target and the biased substrate.

~~3. The sputter deposition system of claim 1 wherein the substrate biasing system includes one of an AC source and a pulsed DC source for biasing the substrate during sputter deposition.~~

~~4.~~³ The sputter deposition system of claim ~~2~~¹ wherein the biasing source operates under 200 MHz.

~~5.~~⁴ The sputter deposition system of claim ~~3~~¹ wherein the biasing source operates under 20 MHz.

~~6.~~⁵ The sputter deposition system of claim 1 wherein the substrate biasing system includes a DC source for biasing the substrate with DC voltage during sputter deposition.

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The sputter deposition system of claim 1 wherein the substrate biasing system is operable to bias the substrate in the range of 10 to 5000 Volts.

1-8. A sputter deposition system including a vacuum chamber containing a sputtering plasma therein for sputter depositing a layer of material into substrate contacts having very small dimensions, the sputter deposition system comprising:

a target of deposition material positioned in the vacuum chamber and coupled to a target bias source for negatively biasing the target such that ions from the sputtering plasma bombard the target and produce material particles to deposit on a surface of a substrate in the chamber and into the substrate contacts;

a collimator positioned opposite the target and configured to intercept sputtered particles of a predetermined angular incidence to the substrate surface to promote uniform deposition into the substrate contacts.

an electrical biasing system operably coupled to the substrate during sputter deposition, the biasing system operable to negatively bias the substrate such that ions from the sputtering plasma bombard the substrate surface and effectively etch the surface generally contemporaneously with the sputter deposition and redistribute the deposited particles in the contacts to reduce

deposition overhang in the contacts and to promote uniform deposition into the contacts;

whereby substrate contacts having large aspect ratios may be uniformly coated with a layer of material and filled with material with reduced numbers of voids.

the collimator being operably coupled to the substrate biasing system and the target bias source and acts as a common reference potential to both the target and the biased substrate;

9.8

A sputter deposition system for sputter depositing a layer of material into substrate contacts having very small dimensions, the sputter deposition system comprising:

a vacuum chamber;

a gas supply for providing gas into the chamber;

an excitation system for exciting the gas into a sputtering plasma containing ions;

a support for supporting, inside the chamber, a substrate with contacts having small dimensions;

a target support for supporting a target of deposition material in the chamber opposite the substrate support, the target support ^{couple to a target bias source} operable to bias a target thereon such that ions from the sputtering plasma bombard the target and produce material particles to deposit on a surface of the substrate and into the contacts;

a collimator positioned between the target support and the substrate support and configured to intercept sputtered particles of a predetermined angular incidence to the substrate surface to promote uniform deposition into and to promote voidless filling of the substrate contacts;

an electrical biasing system operably coupled to the substrate support during sputter deposition, ~~to bias the substrate~~ *the biasing system operable for biasing*
~~thereon~~ such that ions from the sputtering plasma bombard the substrate surface and effectively etch the surface *generally* contemporaneously with the sputter deposition and redistribute the deposited particles in the contacts to reduce deposition overhang in the contacts and to further promote uniform deposition into the contacts;

whereby substrates with contacts having very small aspect ratios may be uniformly coated with a layer of material and filled with material with reduced numbers of voids.

the collimator being operably coupled to the substrate biasing system and the target bias source and acting as a common reference potential to both the target and the biased substrate;

~~10. The sputter deposition system of claim 9 wherein the collimator is operably coupled to the substrate biasing system and the biased target support and acts a common reference potential to both the target and the biased substrate.~~

11.⁹ The sputter deposition system of claim 8⁸ wherein the target support is operable to bias the target in the range of approximately 10 to 1,000 volts.

12.¹⁰ The sputter deposition system of claim 8⁸ wherein the substrate biasing system is operable to bias the substrate in the range of approximately 10 to 5,000 Volts.

13.¹¹ The sputter deposition system of claim 8⁸ wherein the substrate biasing system includes one of an AC source and a pulsed DC source for biasing the substrate during sputter deposition.

14.¹² The sputter deposition system of claim 13¹¹ wherein the biasing source operates between approximately DC and 20 MHz.

~~15.~~¹³ The sputter deposition system of claim ~~13~~¹¹ wherein the AC or pulsed DC source operates between approximately 100 kHz and 20 MHz.

~~16.~~¹⁴ The sputter deposition system of claim ~~8~~⁸ wherein the substrate biasing system includes a DC source for biasing the substrate with DC voltage during sputter deposition.

17.15

A method of sputter depositing a layer of material into substrate contacts having very small dimensions comprising:

positioning a substrate in a vacuum chamber;

exciting a sputtering plasma containing ions within the chamber;

positioning a target of deposition material in the chamber opposite the substrate and biasing the target such that ions from the sputtering plasma bombard the target to produce the deposition of sputtered material particles onto a surface of the substrate and into contacts formed in the substrate surface;

intercepting sputtered particles of a predetermined angular incidence to the substrate surface to promote uniform deposition into and promote voidless filling of the substrate contacts;

by positioning a collimator between the target and substrate to intercept sputtered particles and electrically coupling the substrate and the target to the collimator such that the collimator acts as a common reference potential to both the target and the substrate;

biasing the substrate such that ions from the sputtering plasma bombard the substrate surface and effectively

etch the surface generally contemporaneously with the sputter

deposition and redistribute the deposited particles in the contacts to

reduce deposition overhang in the contacts and to further promote

uniform deposition into the contacts;

whereby substrates with contacts having large aspect ratios may be uniformly coated with a layer of material and filled with material with reduced numbers of voids.

18. ~~The method of claim 17 wherein the intercepting step includes positioning a collimator between the target and substrate to intercept sputtered particles, the method further comprising electrically coupling the substrate and the target to the collimator such that the collimator acts as a common reference potential to both the target and the biased substrate.~~

~~19.~~¹⁶ The method of claim ~~17~~¹⁵ further comprising negatively biasing the substrate to etch the substrate surface with positively biased ions from the plasma.

~~20.~~¹⁷ The method of claim ~~17~~¹⁵ further comprising biasing the target in the range of approximately 10 to 1,000 Volts.

~~21.~~¹⁸ The method of claim ~~17~~¹⁵ further comprising biasing the substrate in the range of approximately 10 to 5,000 Volts.

~~22.~~¹⁹ The method of claim ~~17~~¹⁵ further comprising biasing the substrate with AC voltage during sputter deposition.

~~23.~~²⁰

The method of claim ~~22~~¹⁹ further comprising biasing the substrate between approximately DC and 20 MHz.

~~24.~~²¹

The method of claim ~~22~~¹⁹ further comprising biasing the substrate between approximately 100 kHz and 20 MHz.

~~25.~~²²

The method of claim ~~17~~¹⁵ further comprising biasing the substrate with DC voltage during sputter deposition.

28.²³

A method of sputter depositing a layer of material into substrate contacts having very small dimensions comprising:

positioning a target of material inside of a sputter deposition chamber;

positioning a substrate in the chamber opposite the target with a substrate surface having contacts formed therein facing the target;

bombarding the target with particles from an excited gas plasma to sputter deposit a material layer onto the substrate surface and into the contacts;

bombarding the substrate surface with particles to etch the substrate surface and material layer generally contemporaneously with the sputter deposition of the layer to redistribute the deposited material in the contacts to reduce deposition overhang in the contacts and to promote uniform deposition into the contacts;

whereby substrates with contacts having large aspect ratios may be uniformly coated with a layer of material and filled with material with a reduced number of voids.

intercepting sputtered particles of a predetermined angular incidence to the substrate surface to further promote uniform deposition into the substrate contacts by positioning a collimator between the target and substrate to intercept sputtered particles; electrically coupling the substrate and the target to the collimator such that the collimator acts as a common reference potential to both the target and the substrate;

~~27.~~ ²⁴ The method of claim ~~26~~ ²³ further comprising
intercepting sputtered particles of a predetermined angular
incidence to the substrate surface to further promote uniform
deposition into the substrate contacts.

~~28.~~ ²⁵ The method of claim ~~26~~ ²³ wherein the intercepting step
includes positioning a collimator between the target and substrate
to intercept sputtered particles.

~~29.~~ ²⁶ The method of claim ~~26~~ ²³ further comprising electrically
coupling the substrate and the target to the collimator such that the
collimator acts as a common reference potential to both the target
and the substrate.

²⁴ ~~30.~~ The method of claim ~~26~~ ²³ further comprising biasing the
substrate to etch the substrate surface with positively biased ions
from the plasma.

ABSTRACT**APPARATUS AND METHOD FOR IMPROVED DEPOSITION OF
CONFORMAL LINER FILMS AND PLUGS IN HIGH ASPECT RATIO
CONTACTS****Abstract of the Disclosure**

A sputter deposition system and method comprises a vacuum system (36), target (44), collimator (46), and substrate (38). The target (44) is biased and sputtered to deposit a material layer onto the substrate (38) through the collimator (46). The substrate (38) can be biased to allow contemporaneous etching with deposition. The etching redistributes the deposited material in the contact to reduce overhang at the contact opening and produce a more conformal deposition inside the contact than without substrate bias. The invention is particularly useful for producing conformable liners and void-free filling of sub-micron contacts having high aspect ratios.