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(54) BURN-IN PROCESS FOR HIGH DENSITY PLASMA PVD CHAMBER

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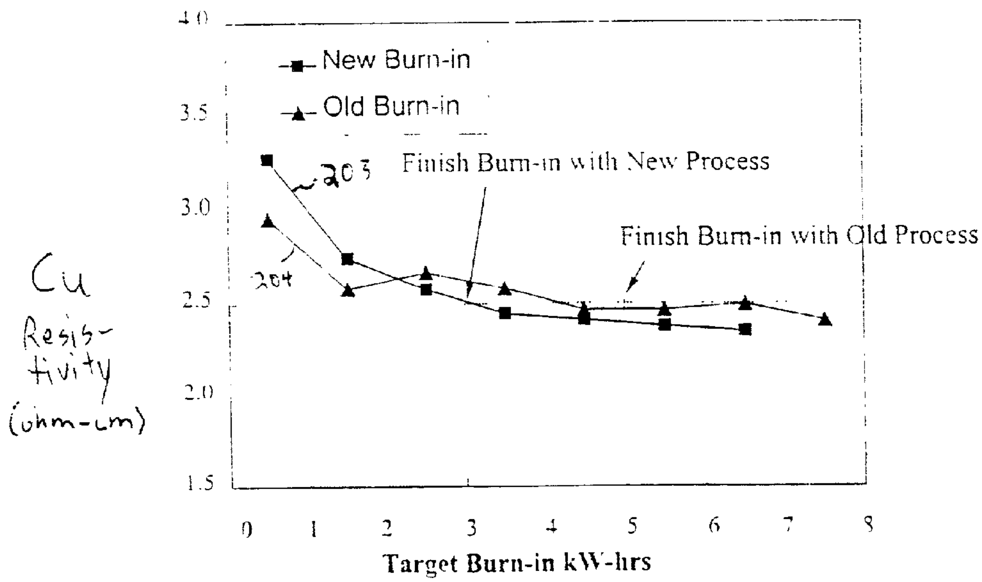
(57) **ABSTRACT**

A burn-in process is performed in a high density plasma sputtering chamber to remove contaminants from a coil and a sputtering target installed in the chamber. The process includes applying respective power signals to the coil and to the sputtering target while maintaining a pressure level in the chamber that is lower than the conventional pressure level of 40 mT. Preferably the pressure level is maintained at substantially 10 mT.



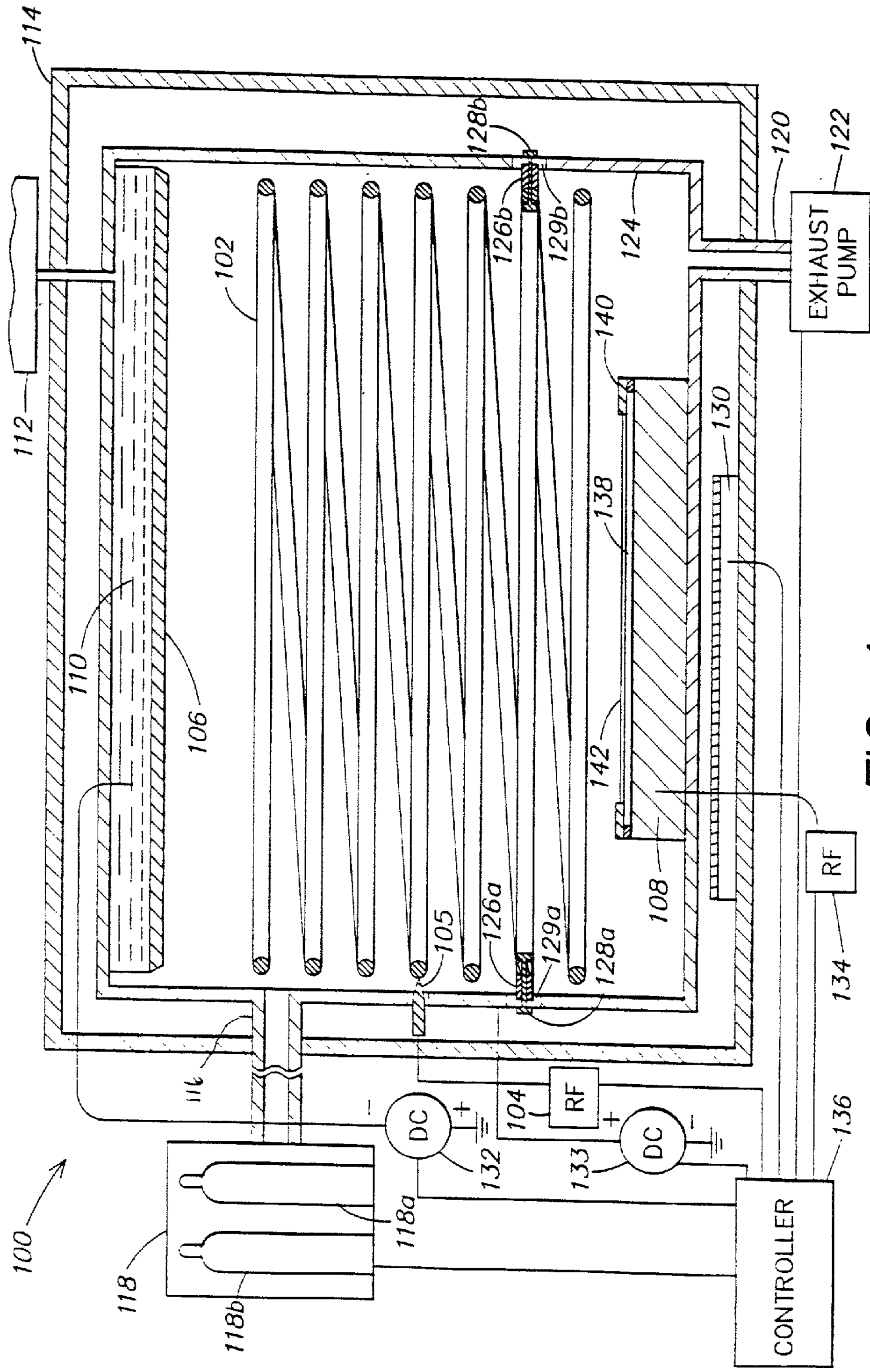


FIG. 1
(PRIOR ART)

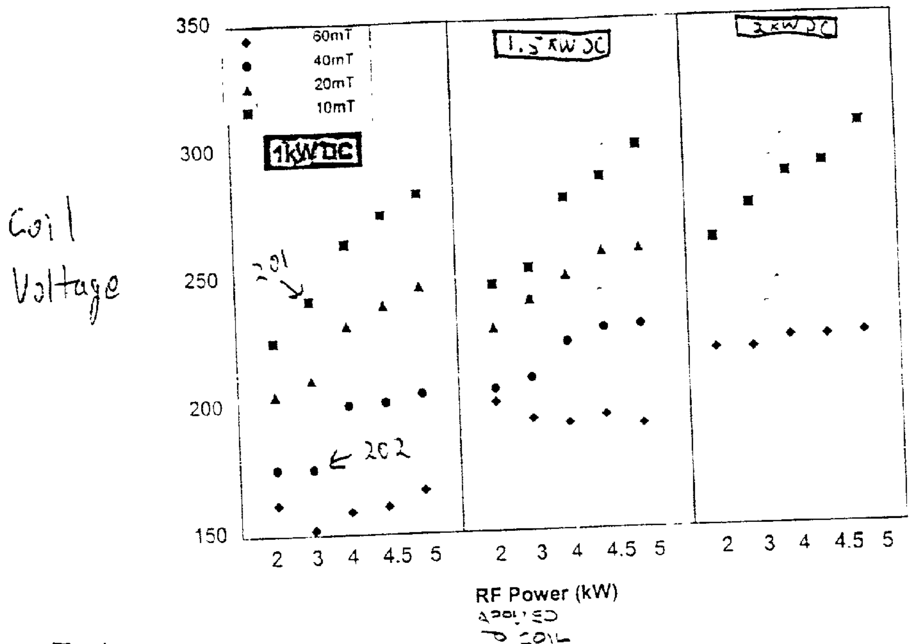
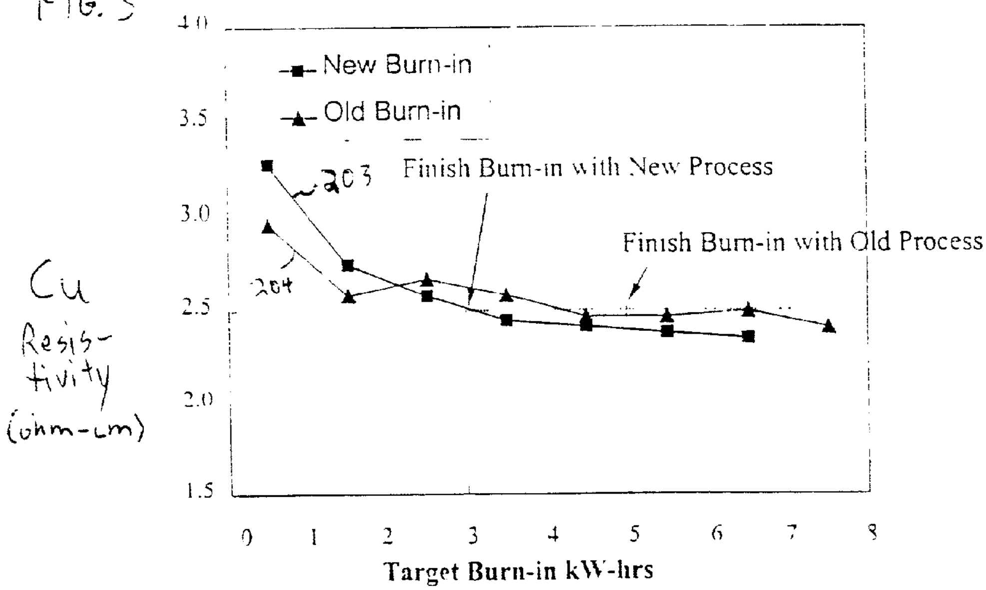

350
300
250
200
150
60mT
40mT
20mT
10mT
1kW DC
1.5 kW DC
3 kW DC
Coil Voltage
201
202
2
3
4
4.5
5
RF Power (kW)
applied to coil

FIG. 2

FIG. 3


4.0
3.5
3.0
2.5
2.0
1.5
New Burn-in
Old Burn-in
203
204
Finish Burn-in with New Process
Finish Burn-in with Old Process
Cu Resis-tivity (ohm-cm)
0
1
2
3
4
5
6
7
8
Target Burn-in kW-hrs

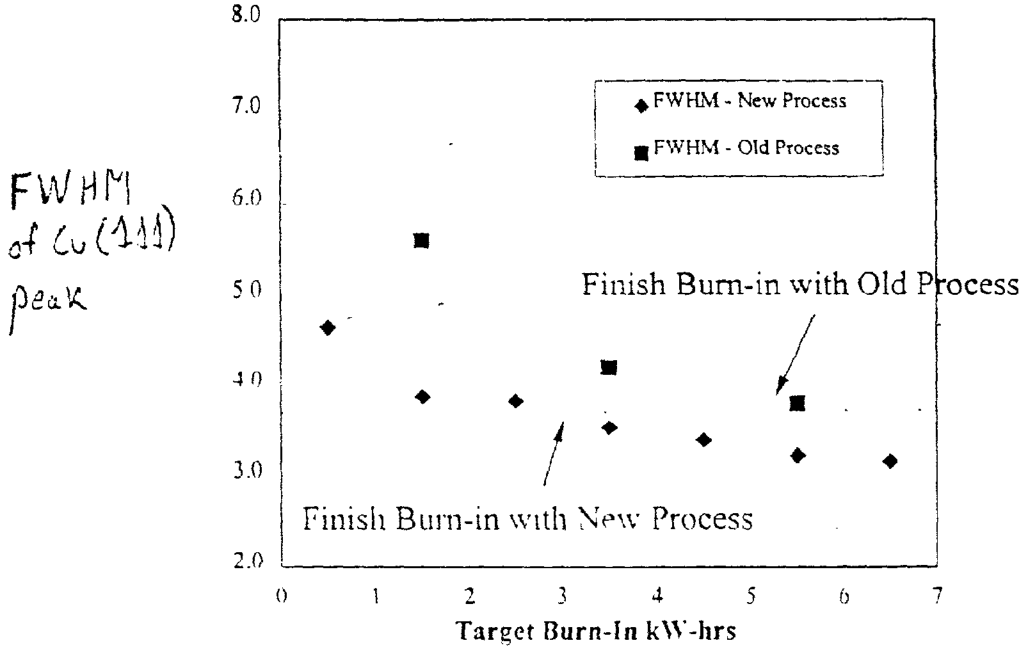

FWHM of Cu(111) peak
8.0
7.0
6.0
5.0
4.0
3.0
2.0
FWHM - New Process
FWHM - Old Process
Finish Burn-in with Old Process
Finish Burn-in with New Process
0
1
2
3
4
5
6
7
Target Burn-In kW-hrs

FIG. 4

BURN-IN PROCESS FOR HIGH DENSITY PLASMA PVD CHAMBER

FIELD OF THE INVENTION

[0001] The present invention relates generally to semiconductor device manufacturing, and more particularly to a burn-in process employed in an high density plasma physical vapor deposition (HDPPVD) chamber.

BACKGROUND OF THE INVENTION

[0002] **FIG. 1** is a side diagrammatic illustration, in section, of the pertinent portions of a conventional high density plasma (HDP) sputtering or physical vapor deposition (PVD) chamber **100**. The sputtering chamber **100** contains a coil **102** which is operatively coupled to a first RF power supply **104** via one or more feedthroughs **105**. The coil **102** may comprise a plurality of coils, a single turn coil, a single turn material strip, or any other similar configuration. The coil **102** is positioned along the inner surface of the sputtering chamber **100**, between a sputtering target **106** and a substrate pedestal **108**. Both the coil **102** and the target **106** are formed from the to-be-deposited material (e.g., copper, aluminum, titanium, tantalum, etc.).

[0003] The substrate pedestal **108** is positioned in the lower portion of the sputtering chamber **100** and typically comprises a pedestal heater (not shown) for elevating the temperature of a semiconductor wafer or other substrate supported by the substrate pedestal **108** during processing within the sputtering chamber **100**. The sputtering target **106** is mounted to a water cooled adapter **110** in the upper portion of the sputtering chamber **100** so as to face the substrate receiving surface of the substrate pedestal **108**. A cooling system **112** is coupled to the adapter **110** and delivers cooling fluid (e.g., water) thereto.

[0004] The sputtering chamber **100** generally includes a vacuum chamber enclosure wall **114** having at least one gas inlet **116** coupled to a gas source **118** and having an exhaust outlet **120** coupled to an exhaust pump **122** (e.g., a cryopump or a cryoturbo pump). The gas source **118** typically comprises a plurality of processing gas sources **118***a*, **118***b* such as a source of argon, helium and/or nitrogen. Other processing gases may be employed if desired.

[0005] A removable shield **124** that circumferentially surrounds the coil **102**, the target **106** and the substrate pedestal **108** is provided within the sputtering chamber **100**. The shield **124** may be removed for cleaning during chamber maintenance, and the adapter **110** is coupled to the shield **124** (as shown). The shield **124** also supports the coil **102** via a plurality of cups **126***a-b* attached to, but electrically isolated from the shield **124**, and via a plurality of pins **128***a-b* coupled to both the cups **126***a-b* and the coil **102**. The coil **102** is supported by resting the coil **102** on the pins **128***a-b* which are coupled to the cups **126***a-b*. The cups **126***a-b* and the pins **128***a-b* comprise the same material as the coil **102** and the target **106** (e.g., copper) and are electrically insulated from the shield **124** via a plurality of insulating regions **129***a-b* (e.g., a plurality of ceramic regions). The sputtering chamber **100** also includes a plurality of bake-out lamps **130** located between the shield **124** and the chamber enclosure wall **114**, for baking-out the sputtering chamber **100**.

[0006] The sputtering target **106** and the substrate pedestal **108** are electrically isolated from the shield **124**. The shield **124** may be grounded so that a negative voltage (with respect to grounded shield **124**) may be applied to the sputtering target **106** via a first DC power supply **132** coupled between the target **106** and ground, or may be floated or biased via a second DC power supply **133** coupled to the shield **124**. Additionally, a negative bias may be applied to the substrate pedestal **108** via a second RF power supply **134** coupled between the pedestal **108** and ground. A controller **136** is operatively coupled to the first RF power supply **104**, the first DC power supply **132**, the second DC power supply **133**, the second RF power supply **134**, the gas source **118** and the exhaust pump **122**. The controller **136** includes computer program code adapted to control various operating parameters of the chamber **100** including the power levels provided by the power supplies **104**, **132**, **133**, **134** and the pressure level in the chamber **100**.

[0007] To perform deposition within the sputtering chamber **100**, a substrate **138** (e.g., a semiconductor wafer, a flat panel display, etc.) is loaded into the sputtering chamber **100**, is placed on the substrate pedestal **108** and is securely held thereto via a clamp ring **140**. An inert gas such as argon then is flowed from the gas source **118** into the high density plasma sputtering chamber **100** and the first DC power supply **132** biases the sputtering target **106** negatively with respect to the substrate pedestal **108** and the shield **124**. In response to the negative bias, argon gas atoms ionize and form a plasma within the high density plasma sputtering chamber **100**. An RF bias preferably is applied to the coil **102** via the first RF power supply **104** to increase the density of ionized argon gas atoms within the plasma and to ionize target atoms sputtered from the target **106** (as described below).

[0008] Because argon ions have a positive charge, argon ions within the plasma are attracted to the negatively biased sputtering target **106** and strike the sputtering target **106** with sufficient energy to sputter target atoms from the target **106**. The RF power applied to the coil **102** increases the ionization of the argon atoms, and, in combination with the coupling of the coil power to the region of argon and sputtered target atoms, results in ionization of at least a substantial portion of the sputtered target atoms. The ionized, sputtered target atoms travel to and deposit on the substrate **138** so as to form over time a continuous target material film **142** thereon. Because the sputtered target atoms are ionized by the coil **102**, the target atoms strike the substrate **138** with increased directionality under the influence of the electric field applied between the target **106** and the substrate pedestal **108** (e.g., by the first DC power supply **132**). The second RF power supply **134** may be employed to apply a negative bias to the substrate pedestal **108** relative to both the sputtering target **106** and to shield **124** to further attract sputtered target atoms to the substrate **138** during deposition.

[0009] In addition to target atoms, coil atoms are sputtered from the coil **102** during deposition and deposit on the substrate **138**. Because of the coil's proximity to the wafer's edge the sputtered coil atoms predominantly coat the substrate **138** near its edges and, where the flat target atoms tend to deposit a center thick layer, result in overall uniformity of the thickness of the film **142** deposited on the substrate **138**. Following deposition, the flow of gas to the high density

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