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ABSTRACT OF THE DISCLOSURE

3 The resistivity of titanium nitride films is reduced, by about 40 % (to less than
4 about 60 μ Ohm-cm), for example; and, the film surface roughness is reduced, by
5 about 45 % (to less than 6 Å) by using a combination of particular process conditions
6 during deposition of the film. In particular, titanium atoms produced by impact of
7 inert gas ions upon a titanium target travel through a high density, inductively coupled
8 rf plasma, an ion metal plasma (IMP), in which the titanium atoms are at least
9 partially ionized. The ionized titanium ions are contacted with ionized nitrogen atoms
10 also present in the processing chamber. The resultant gas phase composition is
11 contacted with the surface of a semiconductor substrate on which a titanium nitride
12 barrier layer is to be deposited. By controlling the gas phase deposition mixture
13 composition, the quantity of the deposition mixture contacting the substrate surface
14 over a given time period, and the pressure in the process vessel, the resistivity and
15 surface roughness of the titanium nitride layer is adjusted. The resistivity of the
16 titanium nitride barrier layer is principally determined by the crystal orientation of the
17 titanium nitride. The more nearly the crystal orientation approaches 100 % of the
18 {200} orientation (the lower the percentage of {111} orientation), the lower the film
19 resistivity. Crystal orientation is obtained by increasing the ionized content of the
20 deposition mixture and by slowing the rate of deposition of the titanium nitride film
21 (barrier layer). The surface roughness of the titanium nitride layer is reduced
22 principally by reducing the pressure in the process vessel, which affects the film
23 formation dynamics. An increase in ionized content of the deposition mixture helps
24 reduce surface roughness until an inflection point is reached, after which surface
25 roughness increases with increased ionized content.

