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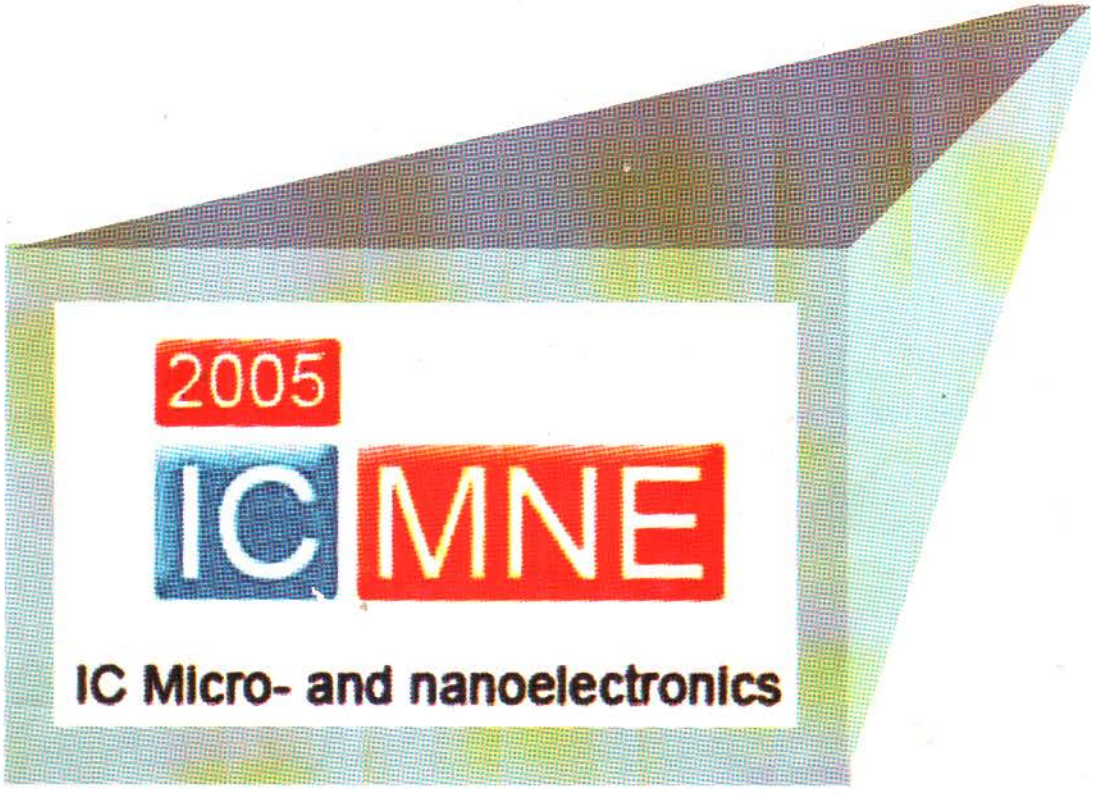

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ABSTRACTS

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Ionized PVD with an electron cyclotron resonance plasma source

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The ionized physical vapor deposition (IPVD) method is much used to deposit materials into high-aspect ratio integrated circuit features such as vias and trenches. There are, further application, such as formation of compound films, multilayer films or superlattice coatings, where an enhanced chemical reactivity of the gases and a smooth surface of the films are required. High density plasma sources, such as a magnetron with an inductively coupled plasma, a hollow cathode magnetron or an electron cyclotron resonance (ECR) plasma source are used to ionize the sputtered neutrals [1-4].

In this report ionization of sputtered metal atoms in the plasma of an ECR discharge has been studied. The feature of ECR plasma is a low pressure sputter deposition of thin films grown under an intensive ion assistance. The system consisted of a 15 cm in diameter by 25 cm - long source from which plasma diffuses into a 35 cm in diameter by 60 cm - long reactor. The magnetic field was produced by three electromagnets and twelve permanent Sm-Co magnets. A hollow 10 cm long metal (Al, Cu, Ti) cylinder with inner diameter of 16 cm served as a target. The target was located at z = 40 cm from the entrance quartz window. A plasma density up to 10^{12} cm^{-3} was attained at pressure 1 mTorr at this location. The power supplied to the target was varied within the 200 – 900 W range.

The spatial distributions of ion density, floating and plasma potentials, temperature T_e and energy distribution function of electrons was measured by a probe. Optical emission spectroscopy was used to monitor trends in ionisation fractions for metal deposition plasmas. Optical absorption spectroscopy was used to determine of sputtered atom density. The random and directed energies of sputtered atoms were found by means of a pressure scanned Fabry-Perot interferometer.

The deposition experiments were carried out for evaluation of fill characteristics. The metal atoms and ions were deposited on a samples that were hold on a water – cooled aluminium disk, positioned 15 cm behind the target. The samples were Si wafers prepared with a SiO_2 dielectric layer. The substrate was under floating potential, energy of the ions on a substrate was in a range 15-25 eV. Trenches were etched into the dielectric layer, with depth of 0.8 - 3.5 μm and various width - from 1.2 up to 0.7 μm, presenting a variety of aspect ratios up to 4.5.

Scanning electron microscopy cross sections revealed anisotropic character of a trench filling, which had been defined by a stream of ions of metal. Metal ion flux fraction was estimated from direct measurements of the film thickness at the trench bottom and the top surface. Ionization fractions of aluminum and titanium flux up to 70 % and copper of 45 % were derived from this analysis. These values are in agreement with the results received from probe and optical measurements. It is significant that metallization of structures was carried out at pressure less than 1 mTorr.

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