# International Conference
# “Micro- and nanoelectronics – 2007”

2007

ICMNE

IC Micro- and nanoelectronics

## *Book of*
# ABSTRACTS

**October 1st - 5th, 2007**
**Moscow – Zvenigorod, Russia**

# Ionized metal PVD with a hollow cathode magnetron

N. Poluektov, V. Kharchenko, I. Kamyschov, Yu. Tsar'gorodsev
*Moscow State Forestry University, Mytischi, Moscow Region, Russia, poluekt@mgul.ac.ru*

The ionized metal physical vapor deposition (IMPVD) method is increasingly used to deposit diffusion barriers and copper seed layers materials into high-aspect ratio vias and trenches for microelectronics fabrication [1-3]. IMPVD typically improves bottom and sidewall coverages in the trench compared to conventional PVD due to there being a larger fraction of ionized species arriving at the wafer. 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.

In this report ionization of sputtered metal atoms in the plasma of hollow cathode magnetron (HCM) has been studied (Fig1). The cathode consists of a cup-shaped Cu target (8 cm i.d. and 5.5 cm long) from which plasma diffuses into a reactor (35 cm diameter, 55 cm length). The magnetic field is produced by twelve columns of Nd-Fe-B magnets surrounded the target with ring iron flanges on the end. Magnetic field inside HCM has maximum field strength of 500 Gs. The downstream electromagnet spreads the extracted plasma beam to achieve desired deposition uniformity on the wafer. The current and power of the target were up to 10 A and 3 kW respectively. Pressure was within range of 0.5 - 10 mTorr.

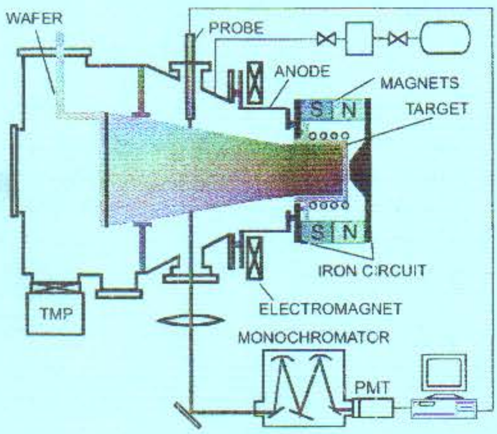


Fig.1. Schematic of the hollow cathode magnetron.

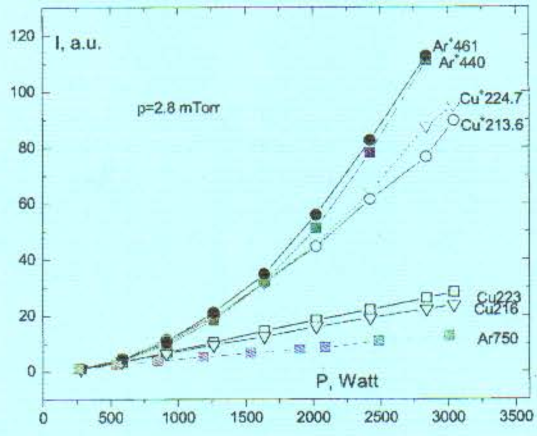


Fig.2. Intensity of the Ar and Cu spectral lines vs magnetron power.

A plasma density exceeding $10^{12}$ $cm^{-3}$ was attained at pressure above 2 mTorr at a distance of 20 cm from the cathode.

The radial and longitudinal distributions of the ion density, floating and plasma potentials, temperature $T_e$ and energy distribution function of the electrons was measured by a probe for various pressures and powers. Optical emission spectroscopy was used to monitor trends in ionization fractions for metal deposition plasmas. Figure 2 shows normalized intensities of atom and ion spectral lines versus magnetron power. As can be seen from plots, intensity of metal ions grows much more than that of atoms with increase of power. Ionization fractions of copper flux over 40 % was achieved.

This work was supported by RFBR, grant 05-08-33486.

1. J. Hopwood, "Ionized physical vapor deposition of integrated circuit interconnects", Physics of Plasmas, **5**, pp.1624-1631, 1998.
2. E. Klawuhn, G.C. D'Couto, K.A. Ashtiani, P. Rymer, M.A. Biberger, K.B. Levy, "Ionized physical-vapor deposition using a hollow-cathode magnetron source for advanced metallization", J.Vac.Sci.Technol., **A18**, pp.1546-1549, 2000.
3. V.Vyas, M.J.Kushner, "Scaling of hollow cathode magnetrons for ionized metal physical vapor deposition", J. Vac.Sci.Technol., **A24**, pp.1955-1969, 2006.