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Zinc oxide coating of silicon substrates by means of plasma immersion ion implantation and deposition

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Abstract – Deposition of zinc oxide thin film on silicon substrate was performed by means of Plasma Immersion Ion Implantation and Deposition (PIII&D). Top view images obtained by SEM revealed the presence of precipitates with uniform distribution along the silicon surface, being identified as ZnO by EDS analysis. The thickness of the deposited layer varied from 90 nm to 1,2 μm, depending on the condition of the treatment. AFM measurements indicated mean roughness of about 70 nm. Treated samples will be submitted to Raman spectroscopy in order to verify the presence of photoluminescence. XPS and high resolution XRD will be performed soon.

The intrinsic semiconducting characteristics of zinc oxide of wide direct band gap (3.37 eV) and large excitation biding energy (60 mV) led to broad range of possible applications for this material, including light-emitting devices, solar cells, short wavelength optoelectronic devices and so on. In addition, inherent piezoelectricity of ZnO structure finds application in the construction of sensors and transducers, e.g.

This paper shows a new process for coating silicon with ZnO without a buffer layer. It consists on the implantation of zinc into the surface of the silicon and post-deposition of ZnO onto this substrate. In the process, small pieces of metallic zinc filling the top of a crucible are immersed in an argon plasma; the crucible is positively polarized and draw electrons from a cathode, which is composed of a tantalum foil covered with (Ba, Sr, Ca)O. The low workfunction of this cathode is essential to supply enough amount of electrons to heat the crucible to temperatures ranging from 400 to 450 ^{0}C, leading to the vaporization of the zinc. The zinc vapor is partially ionized due to collisions with argon ions and electrons from the plasma. High negative and repetitive voltage pulses (10kV/20μs/250Hz) applied to a sample holder containing the silicon slices causes the implantation of zinc ions into the silicon; between pulses zinc is deposited onto Si substrate. Residual oxygen from the vacuum chamber reacts with deposited zinc to form the ZnO.

SEM images from the top of the coated silicon revealed the presence of precipitates, as shown in figures 1a) and 1b), being identified as ZnO by EDS analysis (figure 2). Diameter of the precipitates varies from hundreds of nanometers (fig. 1a) to tens of nanometers (fig. 1b), depending on the temperature of vaporization of the zinc and the duration of the treatment.

AFM measured a mean roughness of about 70 nm on the treated surface. Tilted images from AFM showed the presence of columns with heights varying from 100 nm to 800 nm.

Si samples will be submitted to Raman spectroscopy in order to verify the presence of photoluminescence. Besides, coated samples will be analyzed by high resolution X-ray diffraction (HRXRD) and XPS.

The mechanism of the growth of perpendicular columns of ZnO on Si surface without a buffer layer will be investigated in details after measurements performed by XPS and HRXRD.

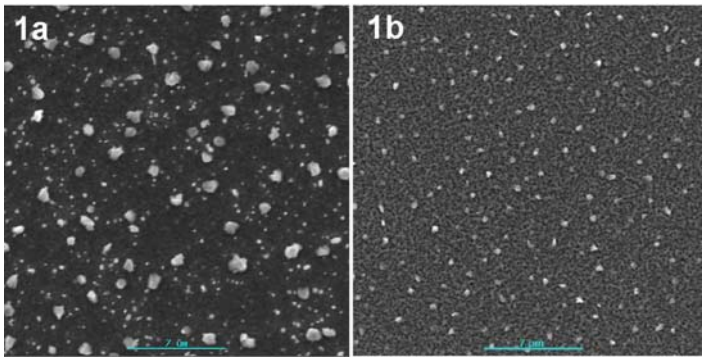

Figure 1: SEM images of Si samples coated with ZnO by PIII&D under two distinct conditions of treatment.

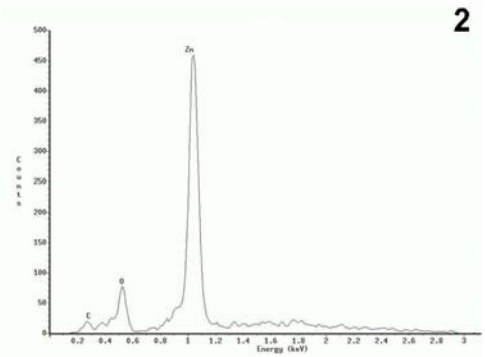

Figure 2: EDS analyses showing the presence of ZnO

References

[1] R. M. Oliveira, M. Ueda, B. Moreno, L. Hoshida, S. Oswald and E. Abramof; Phys. Stat. Sol. (c) 5, No. 4 (2008), 893-896.