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Nanostructured modified thin films for microhumidity measurements

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Abstract – Now, important task is humidity content determination; it is especially for its little concentrations in gases and organic vehicles. The sorption methods have the best characteristics complex for this purpose. The base sensor’s element, that it is independent from way of signal conversion and registration, is substance layer which reversibly sorbs water molecules. Nanostructured SiO_x films, activated with different additives at appropriate conditions can get specified sensor properties. The microhumidity sensors based on such films may be realized as "sandwich type" sensors with active area of 200 x 200 µm or as crystal with sensors great number.

Usually sorption capacitive type sensors based on high porous oxides (SiO_x, TiO_x) or polymer films are widely used for humidity measurements [1, 2].

The properties of films can be varied considerably by introducing different activating additives into them and by film forming technologies. Nanostructured SiO_x films, activated with different additives at appropriate conditions can get specified sensor properties. The method of hydrolytic polycondensation from tetraethyl orthosilicate solutions was used for forming such films in this work. It allows to obtain SiO_x films activated by different hygroscopic salts, which are used as sensitive layers for microhumidity sensors. The sensitive layer’s thickness was 0,2 - 0,3 µm. The films were deposited by sol-gel method from the solutions. This method enables to obtain sensitive thin films with high specific surface at room temperature. The advantage of the method is the possibility to introduce the activating additives directly into the initial solution.

The interdigital structure for measurements was made by microelectronic planar technology. The substrate with size 4 x 8 mm was made from silica. Nickel as electrode material was used. The thickness of the electrodes is between 0,2 - 0,3 mm. The width of finger pairs of electrodes and distance between them are 20 - 100 µm (for various variants). The active area of the sensor is 4 x 4 mm.

The hybrid films adsorption properties were determined by quartz crystal microbalance. A reference generator "Polus-3" (Russia) was used. It enables working in range humidity from - 90 up to + 20 ^{0}C dew point.

Typical surface morphology of investigated films got on scanning electron microscope “Solver-P47” (Russia) is presented in Figure 1. The films have a microglobular structure with dimension about 2-4 nm. Solution composition and technological conditions were chosen to reach highest possible micro pores content. A calculated specific surface area was 400 - 450 m^2/g for different specimens.

Content of LiCl, P_2O_5 and $CaCl_2$ in SiO_x films results in increase adsorption ability for investigated films. And vice versa, films with content of NaCl and KCl have lower adsorption activity than undoped SiO_x films. The sensitivity dependence on humidity content in toluene for different content SiO_x films is presented in Figure 2: film with 10% mass. P_2O_5 has highest sensitivity. It is important to control the environment’s temperature or to stabilize the temperature of the sensor’s surface at measurements.

The microhumidity sensor may be realized as "sandwich type" sensor with active area of 200 x 200 µm or as crystal with sensors great number.

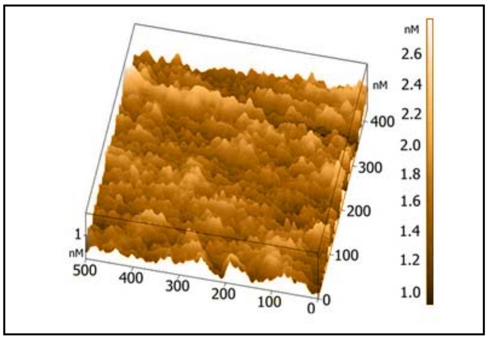

Figure 1: SEM image of hybrid film’s surface

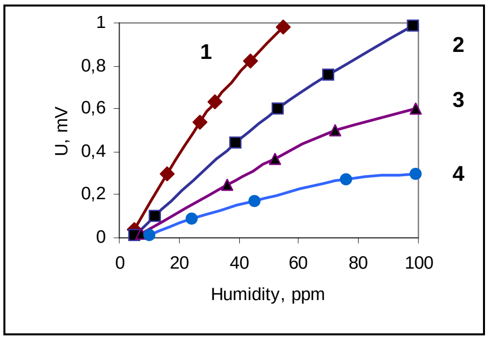

Figure 2: The sensitivity dependence on humidity content in toluene for different content SiO_x films:1-P_2O_5 (10% mass.); 2- P_2O_5 (5% mass.); 3- Li_2O (5% mass.); 4- P_2O_5 (1% mass).

References

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