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Ozone Resistive Sensor

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Field of invention:

Ozone (O_3) is an oxidizing, reactive gas with a specific smell, widely used in disinfecting the atmosphere of premises dedicated to the agri-food industry (*i.e.* fruits and vegetables storage facilities). Its beneficial action as UV-filter in the Earth stratosphere is well known. However, in the ground proximity O_3 is a component of the photochemical smog, and is considered one of the main six pollutants harmful to public health and environment. Severe negative influence to humans' respiratory function and eyes may be caused by exposure to environments with ozone (*i.e.* concentrations of 0.1 ppm - 1 ppm) even for reduced time periods (2h - 6h). Thus, it is very important to monitor the O_3 concentration in the atmosphere of closed spaces, as well as in premises where ozone is used for technological processes.

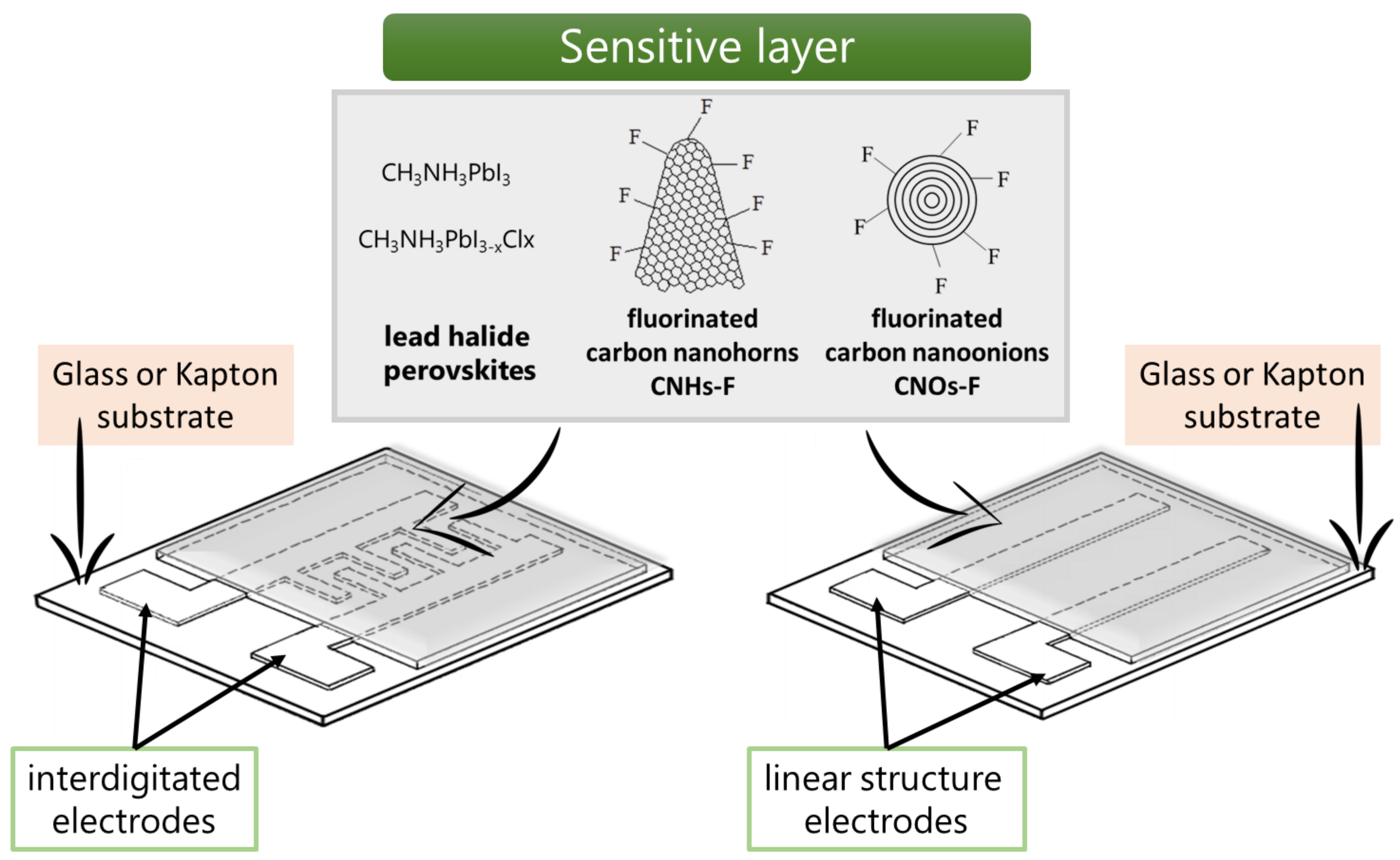
Ozone sensor design and manufacturing

- resistive ozone concentration monitoring sensor that is characterized by the fact that it consists of a dielectric substrate (*e.g.* glass), metal electrodes (*e.g.* Au, Pt) and a thin film of sensitive layer containing a nanocomposite halogenated perovskite and fluorinated nanocarbon materials;
- electrodes may be of the linear type or interdigitated, and are deposited on the dielectric substrate by either direct printing, sputtering or evaporation;
- the ozone-sensitive layer of the halogenated perovskite type / fluorinated nanocarbon materials, is obtained by the successive deposition (*drop casting*) of the fluorinated nanocarbon material, then by the *spin coating* of the $CH_3NH_3PbI_3$ perovskite precursor on the glass substrate with linear electrodes.

Original approach:

The invention describes an ozone resistive sensor using new nanocomposite sensitive layers containing halogenated perovskites ($CH_3NH_3PbI_3$ / $CH_3NH_3PbI_{3-x}Cl_x$ or a mixture of these two) and fluorinated nanocarbon materials (carbon nanohorns CNHs-F or onion-like carbon nanomaterials CNOs-F). Functionalization of the nanocarbon materials is achieved by F_2-N_2 plasma treatment.

O_3 is a molecule with electron-attracting properties, and thus its ad/absorption process is associated with an electron-transfer process from the nanocarbon structure, as both CNHs-F and CNOs-F are p-type semiconductors. By reducing the number of electrons, the holes concentration rises, leading to a proportional decrease of the electrical resistance. Also, once the ozone molecules are ad/absorbed, the unpaired Pb^{2+} cations are passivated, the corresponding decrease of the resistance is proportional to the gas concentration to which the sensitive layer is exposed.



Advantages:

The sensor design by using the sensitive layer with halogenated perovskite nanocomposite / fluorinated nanocarbon materials shows important advantages:

- both nanocarbon materials CNHs-F and CNOs-F offer a high specific surface / volume ratio, and variation of sensitive layer resistance upon contact with ozone molecules;
- halogenated perovskite shows an increased affinity for ozone molecules, and variation of sensitive layer resistance upon contact with O_3;
- due to their increased electronegativity, the fluorine atoms increase the polarity of the surface of the nanocarbon material, creating temporary dipoles that facilitate the interaction with ozone molecules;
- functionalization of nanocarbon materials in fluorine-nitrogen plasma (at various values of power and exposure time) ensure an optimal C:F ratio, an appropriate sensitivity, and a reduced hysteresis;
- reversibility and quick response of the sensor to variations in the ozone concentration value; chemical and thermal stability, superior mechanical properties, detection over a wide temperature range.

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