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Impedance-based analysis of gas sensing using MoS_2 nanostructures

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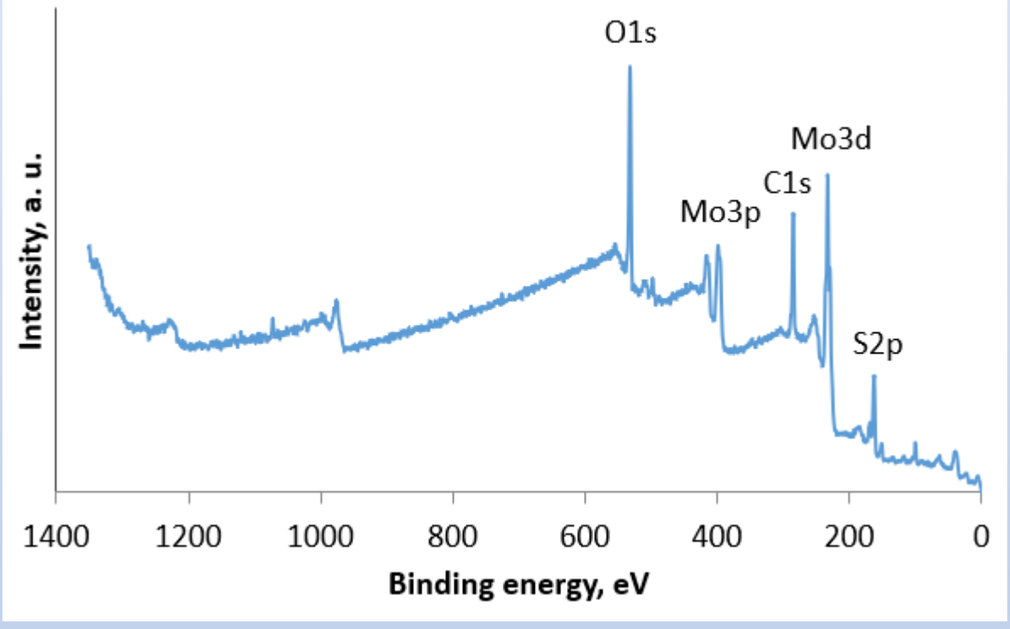
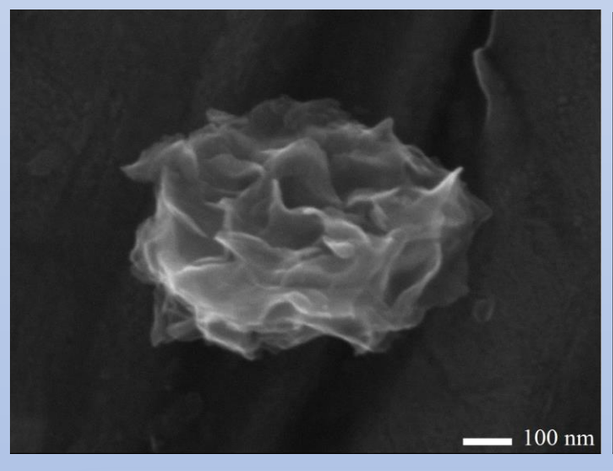
Aim: hydrothermal synthesis of MoS_2 for use as gas sensors operating at room temperature.

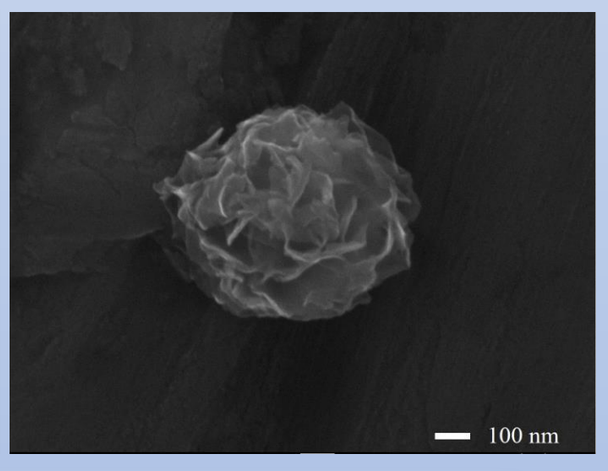
Relevance: MoS_2 has great potential for use in advanced electronic and optoelectronic devices because of its unique properties. Due to the layered structure of MoS_2, it is possible to control the electronic properties by varying the number of layers. This material has shown advantages in gas sensors such as a low detection limit. However, the stability of its characteristics needs improvement.

Synthesis

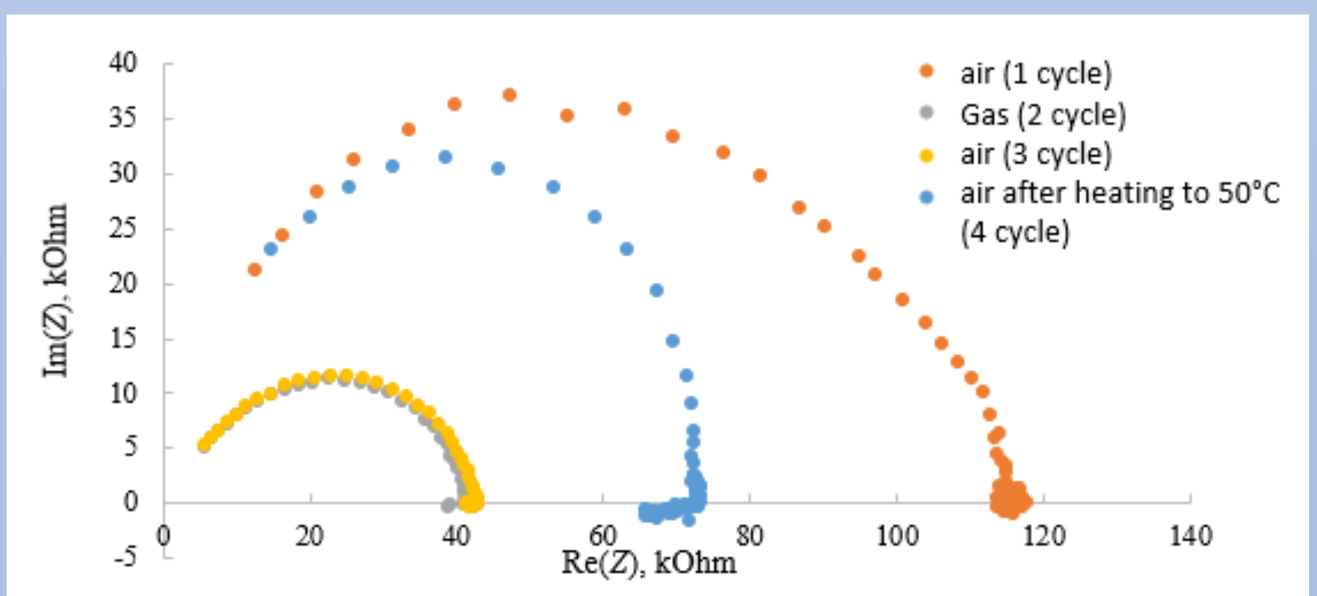
Characterization







Impedance spectroscopy



Nyquist diagram of Sample 1 at room temperature in an air environment, when exposed to vapors of isopropyl alcohol (1000 ppm), recovery in air before and after heat treatment

Response calculated using real part of impedance:

$$S_{\mathrm{Re}} = \mathrm{Re}(Z)_{air}/\mathrm{Re}(Z)_{gas}$$

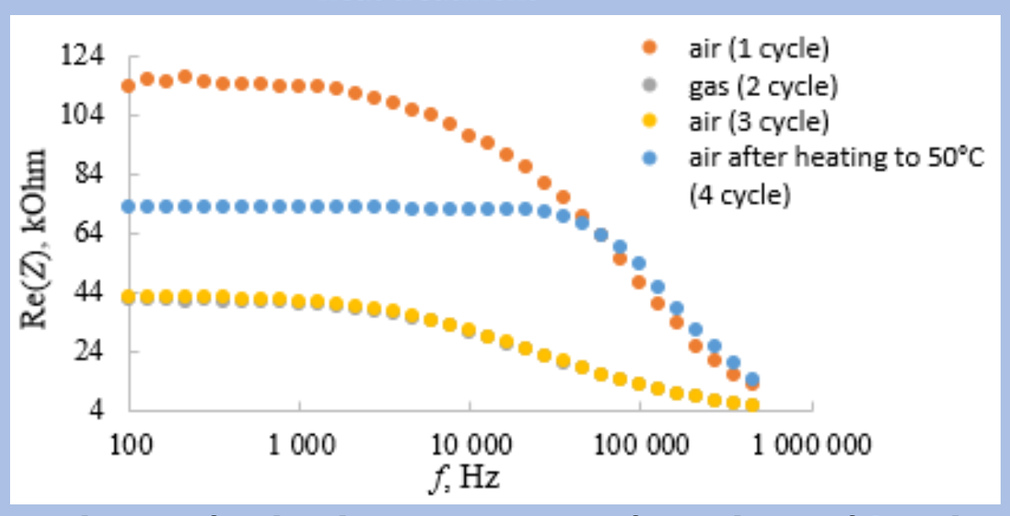
Response calculated using imaginary part of impedance:

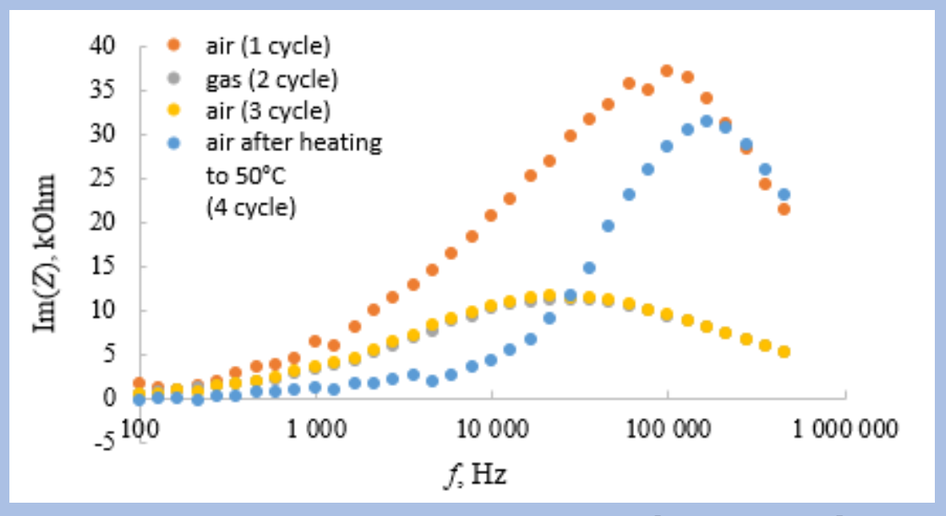
$$S_{\mathrm{Im}} = \mathrm{Im}(Z)_{air}/\mathrm{Im}(Z)_{gas}$$

The highest response:

S_{Re} = **3,8** at 60 kHz;

S_{Im} = **4,3** at 278 kHz.





Frequency dependences of real and imaginary parts of impedance of Sample 1 at room temperature in an air environment, when exposed to vapors of isopropyl alcohol (1000 ppm), recovery in air before and after heat treatment

Conclusions: The MoS_2 sensor layer can detect reducing gas vapors at room temperature using either the real or imaginary component of the impedance as a signal, at frequencies between 100 Hz and 500 kHz. However, in this case, an additional heat treatment at 50 °C is required to recover the sample's properties.

References:

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2. Liang L. et al. Hydrothermal synthesis of the flower-like mos2 nanosheets microspheres and its photocatalytic degradation of methyl orange //Chalcogenide Letters. – 2020. – Т. 17. – №. 11. – С. 555-563.
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