Claims

1. A computerized method of determining respective presence and concentrations of multiple gases and/or volatile organic compounds, the method comprising the steps of:

exposing one or more sensing elements with the same chemical and physical properties to the multiple gases and/or volatile organic compounds;

measuring electrical time series data of the one or more sensing elements during the exposure;

analyzing the electrical time series data other than Lorentzian noise information of the electrical time series data by an Artificial Intelligence (AI) system and analyzing the Lorentzian noise information of the electrical time series data by the Artificial Intelligence (AI) system; and

determining the respective presence and/or concentrations of the multiple gases and/or volatile organic compounds based on the analysis of the electrical time series data other than the Lorentzian noise information of the electrical time series data and the Lorentzian noise information of the electrical time series data.

2. The method of claim 1, further comprising analyzing an ambient temperature by the Artificial Intelligence (AI) system and determining the respective presence and/or concentrations of the multiple gases and/or volatile organic compounds is further based on the analysis of the ambient temperature.

3. The method of claims 1 or 2, wherein the Lorentzian information comprises features selected from a group consisting of the characteristic Lorentzian peak with the maximum power spectral density, their respective power spectral density, the characteristic Lorentzian desorption time the Kurt, Skew, median of the Lorentzian noise spectral, the power spectral density ratio of the characteristic Lorentzian frequency to the median of the Lorentzian noise spectral, the numbers of Lorentzian peaks found in the Lorentzian noise spectral, the median of the Lorentzian peaks, the frequencies associated to the Lorentzian peaks, the full width half maximum and full width full maximum of the characteristic Lorentzian peak.

4. The method of any one of claims 1 to 3, wherein the AI system is a classification or regression model AI system or a reinforcement learning AI system.

5. The method of any one of claims 1 to 4, wherein each sensor element comprises a two-dimensional sensing material.

6. The method of claim 5, wherein the two-dimensional sensing material is configured as a chemiresistor and the electrical time series data comprises resistance time series data.

7. The method of claims 5 or 6, wherein the two-dimensional sensing material comprises one or a group consisting of black Phosphorous (bP), Tellurene, reduced graphene oxide, graphene, and Transition metal dichalcogenides, or any two-dimensional allotropes of various elements or compounds with a carrier mobilities that are comparable to black Phosphorous for low-power operation.

8. A sensor device capable of determining respective presence and concentrations of multiple gases and/or volatile organic compounds, the sensor device comprising:

one or more sensing elements made from a substantially identical sensing material; and

an Artificial Intelligence (AI) system;

wherein the AI system is configured to analyze electrical time series data of the one or more sensing elements other than Lorentzian noise information of the electrical time series data and to analyze the Lorentzian noise information of the electrical time series data and to determine the respective presence and concentrations of multiple gases and/or volatile organic compounds based on the analysis of the analysis of the electrical time series data other than the Lorentzian noise information of the electrical time series data and the Lorentzian noise information of the electrical time series data.

9. The sensor device of claim 8, wherein the AI system is further configured to analyze an ambient temperature and to determine the respective presence and/or concentrations of multiple gases and/or volatile organic compounds further based on the analysis of the ambient temperature.

10. The sensor device of claims 8 or 9, wherein the Lorentzian information comprises features selected from a group consisting of the characteristic Lorentzian peak with the maximum power spectral density, their respective power spectral density, the characteristic Lorentzian desorption time the Kurt, Skew, median of the Lorentzian noise spectral, the power spectral density ratio of the characteristic Lorentzian frequency to the median of the Lorentzian noise spectral, the numbers of Lorentzian peaks found in the Lorentzian noise spectral, the median of the Lorentzian peaks, the frequencies associated to the Lorentzian peaks, the full width half maximum and full width full maximum of the characteristic Lorentzian peak.

11. The sensor device of any one of claims 8 to 10, wherein the AI system is a classification or regression model AI system or a reinforcement learning AI system.

12. The sensor device of any one of claims 8 to 11, wherein each sensing elements comprises a two-dimensional sensing material.

13. The sensor device of claim 12, wherein the two-dimensional sensing material is configured as a chemiresistor and the electrical time series data comprises resistance time series data.

14. The sensor device of claims 12 or 13, wherein the two-dimensional sensing material comprises one or a group consisting of black Phosphorous (bP), Tellurene, reduced graphene oxide, graphene, and Transition metal dichalcogenides, or any two-dimensional allotropes of various elements or compounds with a carrier mobilities that are comparable to black Phosphorous for low-power operation.

15. A method of training a sensor device of any one of claims 8 to 14 to be capable of determining respective presence and/or concentrations of multiple gases and/or volatile organic compounds, comprising analyzing electrical time series data other than Lorentzian noise information of the electrical time series data and analyzing the Lorentzian noise information of the electrical time series data from samples to determine features for the training of the device, wherein the features comprise one or more first features of the electrical time series data other than the Lorentzian noise information of the electrical time series data and one or more features of the Lorentzian noise information of the electrical time series data.

16. The method of claim 15, comprising data collections steps of:

i exposing the one or more sensing elements to a desired number and type of gases and/or volatile organic compounds in a controlled environment and measuring a first dataset of the electrical time series data;

ii varying a concentration of one of the gases and/or volatile organic compounds and measuring a second dataset of the electrical time series data; and

iii repeating step ii over a desired range of concentrations.

17. The method of claim 16, further comprising data collection steps of:

iv varying respective concentrations of two of the gases and/or volatile organic compounds and measuring a further dataset of the electrical time series data; and

v repeating step iv over a desired ranges of combinations of respective concentrations of the two of the gases and/or volatile organic compounds.

18. The method of claim 17, further comprising data collection steps of:

vi repeating steps iv and v, wherein in each repetition, an additional one of the gases and/or volatile organic compounds is added in step iv.

19. The method of any one of claims 16 to 18, further comprising performing machine training on the datasets collected in the data collection steps.

20. The method of claim 19, wherein performing the machine learning comprises training a classification model to predict the number and type of gases and/or volatile organic compounds, and training a regression model to predict the respective concentrations of the gases and/or volatile organic compounds.