Supporting Information

The Emergence of $MnFe_2O_4$ Nanospheres-based Humidity Sensor: A Methodical Investigation by Scanning Kelvin Probe and its Deployment in Multitudinous Applications

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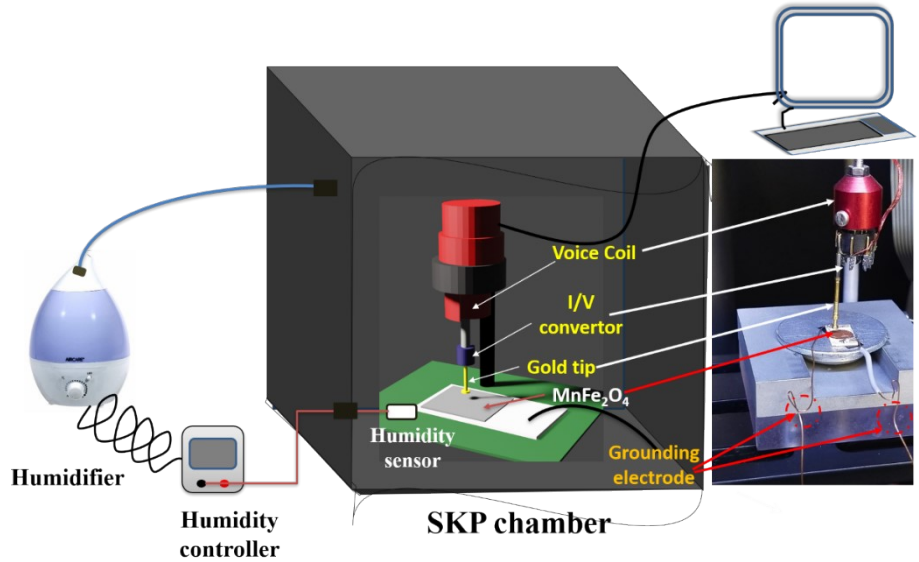

Figure S1. Schematic illustration of Scanning Kelvin Probe System (SKP) measurement setup.

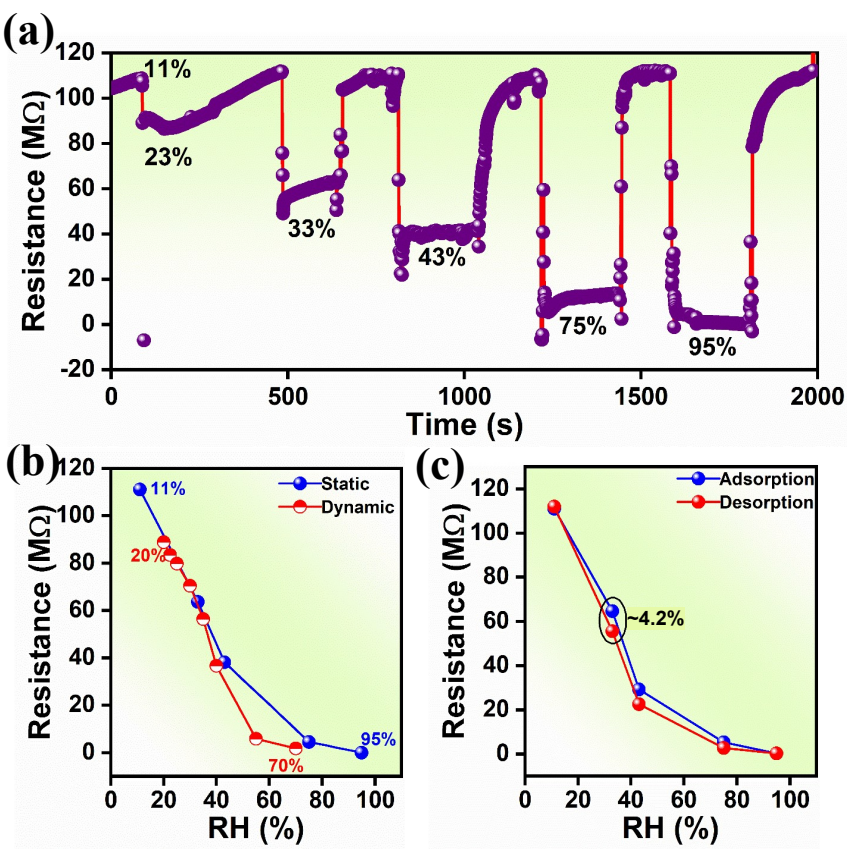

Figure S2. (a) Static sensing test at various humidities, (b) Dynamic and static sensing response curves, (c) Static hysteresis curve.

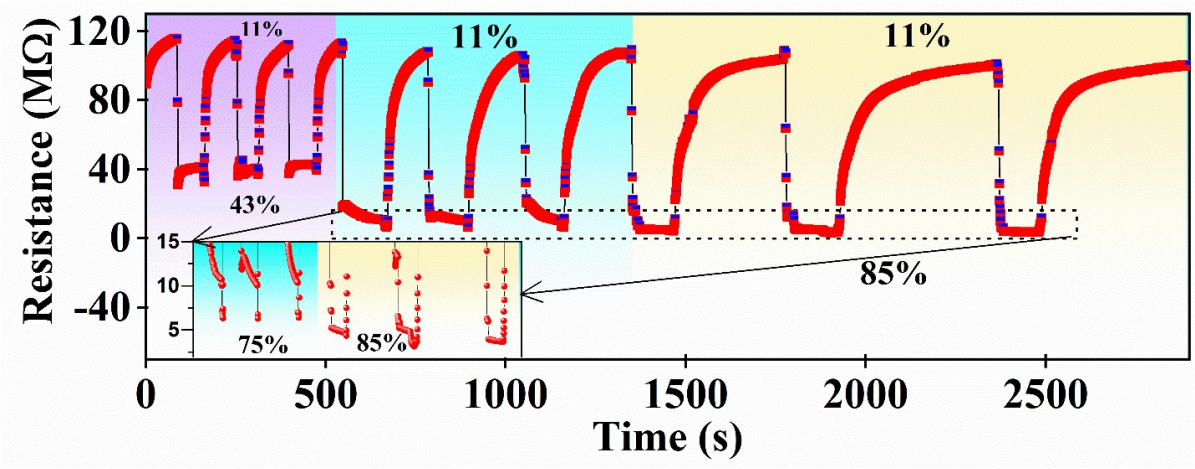

Figure S3. Static sensing test up to 3 cycles for 43%, 75% and 85 %RH. Here the baseline relative humidity is 11%.

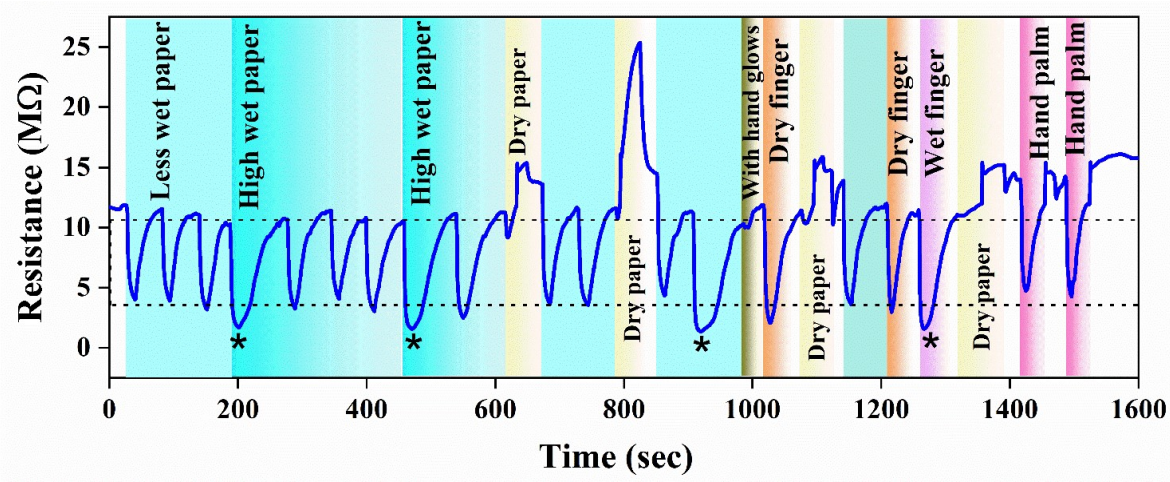

Figure S4. Dynamic response study under influence of different components.

S5: Device fabrication process for baby diaper

For real-time applicability, the sensor was encapsulated in PDMS to avoid direct contact with the objects. The silicone elastomer base and curing agent (10:1) were mixed for 5 min until homogeneous solution was obtained which was then kept in the vacuum desiccator to

remove air bubbles. The resultant PDMS solution was poured into a petri dish to immerse the electrode and was heated at 60°C for 1 h. Furthermore, formed dense jelly type PDMS was peeled out from the dish and PDMS from extra edges as well as on the electrode portion was cut to evoke the electrode region (visual representation given in S1). After cutting, the formed PDMS walls were about ~1mm thick, enough for isolation from the wet object. Finally, the electrode was coated by MFO and heat treated at 150 °C in an oven for 1 h.

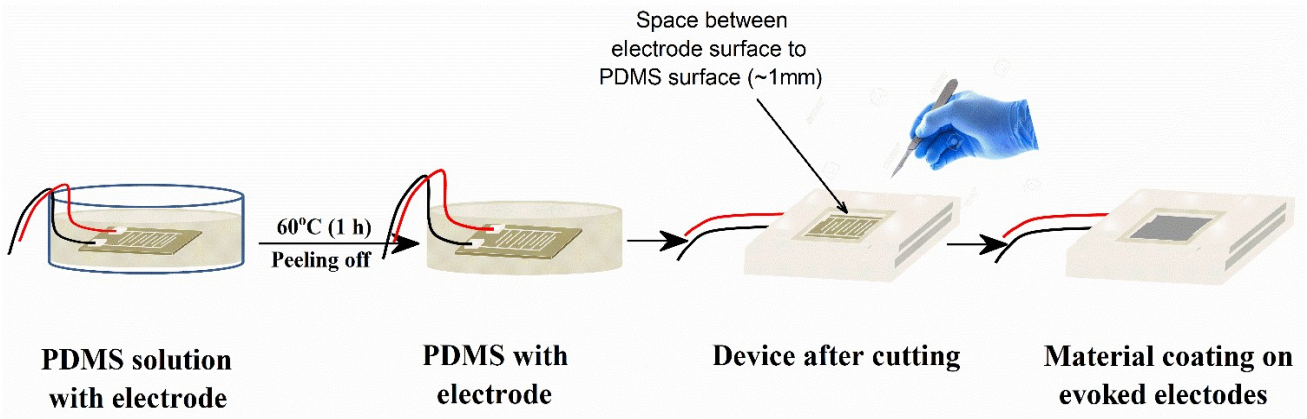

Figure S5. Schematic of process of fabrication of device for baby diaper alarm.

Table S1: Comparison to other ferrite humidity sensor

Sr No.	Material	Measurement	Testing range	Hysteresis	Application	Reference
1	$Cd_{1-x}Ni_xFe_2O_4$ (x=0.5)	Resistance	25-95	-	-	[1]
2	Sn-$NiFe_2O_4$	Impedance	10-95	-	-	[2]
3	$MgFe_2O_4$	Impedance	0-90	-	-	[3]
4	0.3 mol% Pr doped $MgFe_2O_4$	Impedance	10-90	-	-	[4]
5	$CuFe_{(2-x)}Bi_xO_4$ (x= 0.03)	Resistance	11-97	3%	-	[5]
6	Li − $CuFe_2O_4$	Resistance	10-99	-	-	[6]
7	$Mn_{0.95}Bi_{0.05}Fe_{2-x}Ce_xO_4$ (x= 0.03)	Resistance	11-97	3%	-	[7]

8	$Bi_{0.1}CuFe_{1.9}O_4$	Resistance	10-90	-	-	[8]
9	$Ni_{0.7}Mg_{0.3}Y_{0.1}Fe_{1.9}O_4$	Resistance	15-90	7%	-	[9]
10	$Li_xCo_{1-x}Fe_2O_4$ (x=0.5)	Resistance	10-90		-	[10]
11	$MnFe_2O_4$	Resistance	11-95 (static)	5 %	Baby diaper alarm, Skin humidity, etc.	Present work

Movie S1: Baby diaper alarm

References

1 B. Chethan,; Y. T. Ravikiran, S. C. Vijayakumari, H. G. Rajprakash, S. Thomas, *Sensors and Actuators A: Physical,* 2018, **280**, 466–474.

2 V. Manikandan, S. Sikarwar,; B. C. Yadav, R. S. Mane, *Sensors and Actuators A: Physical*, 2018, **272**, 267–273.

3 J. Shah, R. K. Kotnala, *Sensors and Actuators B: Chemical*, 2012, **171**, 832–837.

4 J. Shah, M. Arora, L. P. Purohit, R. K. Kotnala, *Sensors and Actuators A: Physical*, 2011, **167** (2), 332–337.

5 I. C. Sathisha, K. Manjunatha, A. Bajorek, B. R. Babu, B. Chethan, T. R. K. Reddy, Y. T. Ravikiran, V. J. Angadi, *Journal of Alloys and Compounds,3* 2020, **848**, 156577.

6 V. Manikandan, S. Sikarwar, B. C. Yadav, S. Vigneselvan, R. S. Mane, J. Chandrasekaran, A. Mirzaei, *Materials Chemistry and Physics* 2019, **229**, 448–452.

7 Lakshmiprasanna, H. R.; Manjunatha, K.; Husain, *J. Nano-Structures & Nano-Objects* 2020, **24**, 100608.

8 P. Chavan, and L. R. Naik, *Sensors and Actuators B: Chemical,* 2018, **272**, 28–33.

9 P. Rao, R. C. Chikate, S. Bhagwat, *New journal of chemistry,* 2016, **40 (2)**, 1720–1728.

10 P. Chavan, *ACS Omega,* 2021, **6 (3)**, 1953–1959.