Anisotropic Piezoresistive Response of 3D-Printed Pressure Sensor based on ABS/MWCNT Nanocomposite

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Supplementary Information

Tab. 1 | **Commercial ABS Raman spectroscopy data**. The vibrational modes were grouped by region (R) and by respective Lorentzian (L) sequentially. The raw spectra as fitted with r^2=0.98535.

Region-Lorentzian	**Raman shift (cm^{-1})**	**Intensitiy (a.u.)**	**FWHM (cm^{-1})**
R_1-L_1	989.17	55.25	4.05
R_1-L_2	1001.38	1240.40	4.44
R_1-L_3	1030.12	146.24	4.86
R_1-L_4	1033.78	155.06	7.31
R_2-L_5	1156.00	64.65	7.06
R_2-L_6	1181.76	69.15	8.84
R_2-L_7	1188.69	24.07	8.84
R_2-L_8	1198.81	90.35	19.22
R_3-L_9	1445.94	66.05	16.75
R_3-L_{10}	1454.94	34.86	16.85
R_4-L_{11}	1583.26	73.32	5.44
R_4-L_{12}	1601.32	138.49	7.43
R_4-L_{13}	1604.55	78.92	5.02
R_5-L_{14}	1650.14	15.26	20.43
R_5-L_{15}	1667.11	29.93	7.35
R_6-L_{16}	1729.71	43.62	15.77
R_7-L_{17}	2843.71	63.34	14.96
R_7-L_{18}	2871.90	43.67	30.77
R_7-L_{19}	2898.45	65.49	31.68
R_7-L_{20}	2919.24	115.70	34.50
R_7-L_{21}	2947.77	126.71	25.57
R_7-L_{22}	2979.00	37.79	15.78
R_7-L_{23}	3001.54	48.36	30.46
R_7-L_{24}	3035.06	45.60	23.01
R_7-L_{25}	3052.57	92.95	12.81
R_7-L_{26}	3062.82	128.45	19.36

Tab. 2 | **As-received MWCNTs-COOH Raman spectroscopy data**. The raw spectra as fitted with r^2=0.99925.

CNTs Subband	**Raman shift (cm^{-1})**	**Intensitiy (a.u.)**	**FWHM (cm^{-1})**
D*	1134.30	42.64	133.61
D_L	1285.62	61.30	129.30
D_R	1325.58	1328.59	45.28
D_{LO}	1405.40	35.77	102.67
D_{middle}	1494.47	41.83	93.28
G_{out}	1575.15	789.19	39.10
G_{inn}	1602.49	206.58	22.53
D'	1613.22	233.22	19.59
D**	2490.57	24.89	137.36
$2D_L$	2624.32	118.62	86.23
$2D_R$	2650.78	278.06	62.31
D+G	2901.80	45.39	95.17

Tab. 3 | **ABS/MWCNTs-COOH nanocomposite Raman spectroscopy data**. The vibrational modes were labelled as the individual materials. The dislocations are significant above 2 cm^{-1}, considering equipment variations, and redshifts are represented by negative signs. The G* subband was identified only in the nanocomposite spectra. The raw spectra as fitted with r^2=0.99439.

Subband	**Raman shift (cm^{-1})**	**Intensitiy (a.u.)**	**FWHM (cm^{-1})**	**Dislocation (cm^{-1})**
R_1-L_1	987.99	28.55	10.83	-1.18
R_1-L_2	1001.31	711.86	4.56	-0.07
R_1-L_3	1029.75	77.00	5.45	-0.38
R_1-L_4	1033.28	113.29	7.00	-0.50
D*	Not identified			
R_2-L_5	1156.53	59.28	1.38	0.54
R_2-L_6	1183.82	52.22	4.00	2.06
R_2-L_7	1193.41	46.92	6.51	4.72
R_2-L_8	1199.14	61.53	6.73	0.33
D_L	1293.51	55.96	31.54	7.89
D_R	1329.78	1022.26	43.23	4.20
D_{LO}	1377.79	68.29	73.63	-27.61
R_3-L_9	1447.64	120.51	29.62	1.70
R_3-L_{10}	Not identified			
D_{middle}	1508.89	39.03	73.73	14.42
G*	1565.63	133.20	36.09	--
G_{out}	1583.03	322.58	22.16	7.88
R_4-L_{11}	1583.19	41.50	3.13	-0.07
G_{inn}	1601.92	330.28	16.06	-0.57
R_4-L_{12}	1603.42	45.63	3.98	0.92
R_4-L_{13}	Not identified			
D’	1618.02	194.76	17.73	4.80
R_5-L_{14}	Not identified			
R_5-L_{15}	Not identified			
R_6-L_{16}	1731.11	28.81	11.27	1.40
D**	Not identified			
$2D_L$	2649.61	123.24	93.34	25.29
$2D_R$	2706.38	89.70	89.44	55.59
R_7-L_{17}	2844.82	41.03	12.31	1.12
R_7-L_{18}	2871.41	30.06	26.77	-0.49
R_7-L_{19}	2895.79	43.43	30.15	-2.67
D+G	Not identified			
R_7-L_{20}	2917.02	110.02	35.85	-2.22
R_7-L_{21}	2946.88	107.37	28.91	-0.89
R_7-L_{22}	2979.93	22.58	14.15	0.92
R_7-L_{23}	3000.28	23.74	22.58	-1.26
R_7-L_{24}	3034.12	26.64	14.71	-0.94
R_7-L_{25}	3052.78	81.35	13.04	0.22
R_7-L_{26}	3062.71	77.32	16.33	-0.11

Tab. 4 | **Piezoresistive behavior in cycles of increasing pressure**. Mean values and standard deviations from three different samples per group of initial electrical resistance (R), sensitivity (S), response time (t_{res}) and recovery time (t_{rec}) for each cycle of 20 seconds with pressure (P) and 20 seconds without load.

		B group	**C group**
	R	251.59 ± 105.17 kW	366.51 ± 80.63 kW
Cycle 1 P = 68.27 ± 0.22 kPa	S t_{res} t_{rec}	No response	
Cycle 2 P = 139.97 ± 0.46 kPa	S	0.08 ± 0.03 %	0.07 ± 0.03 %
	t_{res}	0.68 ± 0.01 s	0.56 ± 0.20 s
	t_{rec}	2.26 ± 1.87 s	5.76 ± 2.69 s
Cycle 3 P = 213.41 ± 0.47 kPa	S	0.22 ± 0.04 %	0.19 ± 0.06 %
	t_{res}	1.24 ± 0.98 s	1.24 ± 0.52 s
	t_{rec}	3.95 ± 2.88 s	8.36 ± 2.54 s
Cycle 4 P = 288.92 ± 0.29 kPa	S	0.53 ± 0.25 %	0.33 ± 0.11 %
	t_{res}	6.10 ± 6.35 s	1.13 ± 1.09 s
	t_{rec}	7.23 ± 1.53 s	9.60 ± 2.82 s
Cycle 5 P = 363.25 ± 0.39 kPa	S	0.75 ± 0.36 %	0.42 ± 0.12 %
	t_{res}	4.52 ± 6.36 s	1.02 ± 0.90 s
	t_{rec}	10.84 ± 2.06 s	15.02 ± 1.41 s

Tab. 5 | **Piezoresistive behavior in cycles constant pressure**. Mean values and standard deviations from three different samples per group of mean sensitivity (S), mean response time (t_{res}) and mean recovery time (t_{rec}) for 20 cycles with 20 seconds of 363.25 ± 0.39 kPa pressure and 20 seconds without load.

	B group	**C group**
S	0.50 ± 0.10 %	0.38 ± 0.22 %
t_{res}	0.69 ± 0.04 s	0.60 ± 0.08 s
t_{rec}	14.17 ± 1.64 s	15.93 ± 1.12 s