

Supporting Information

Bidirectional Knitted Strain Sensor via AgNWs /MXene Hybridization for Broad-Range Multi- Stage Sensing

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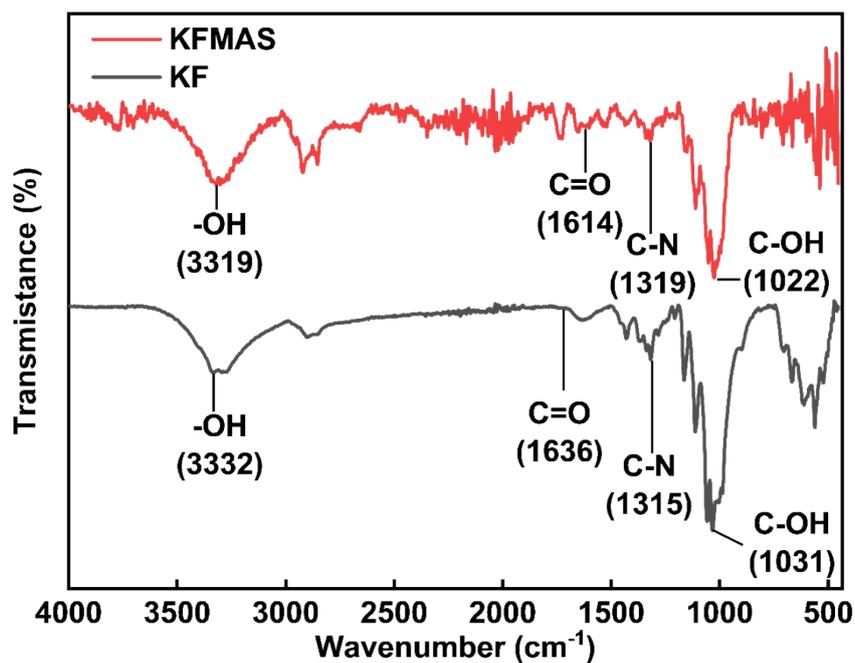


Figure S1 FTIR spectrum of KF and KFMAS.

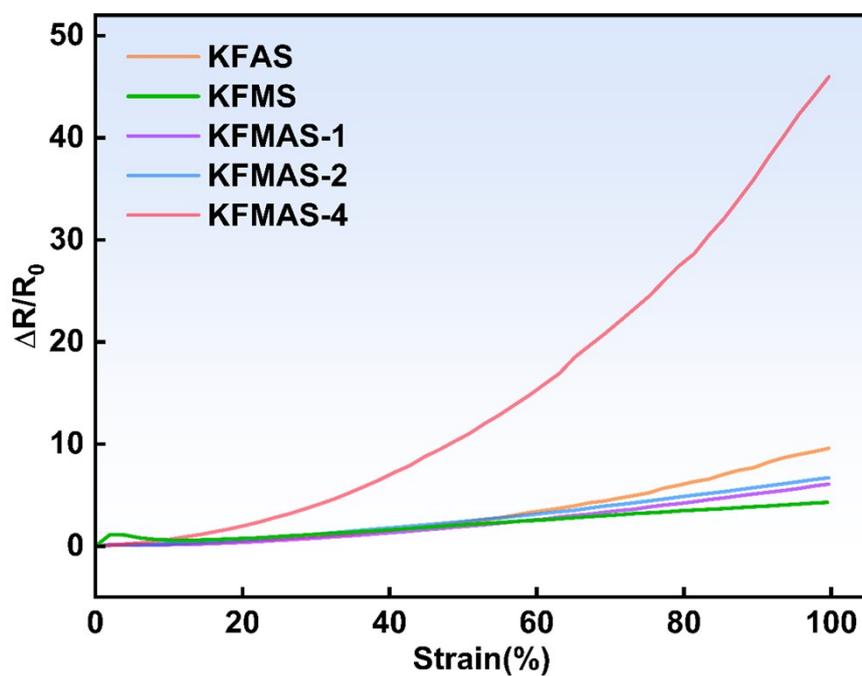


Figure S2 Stretch sensitivity curves of KFAS, KFMS and KFMAS samples.

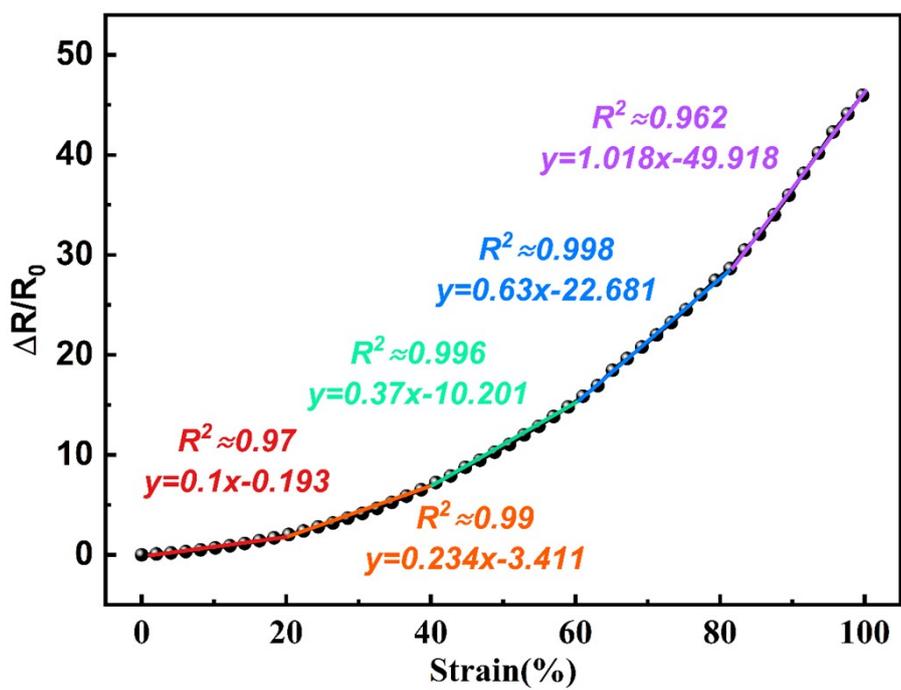


Figure S3 The linearity curve of KFMAS-4.

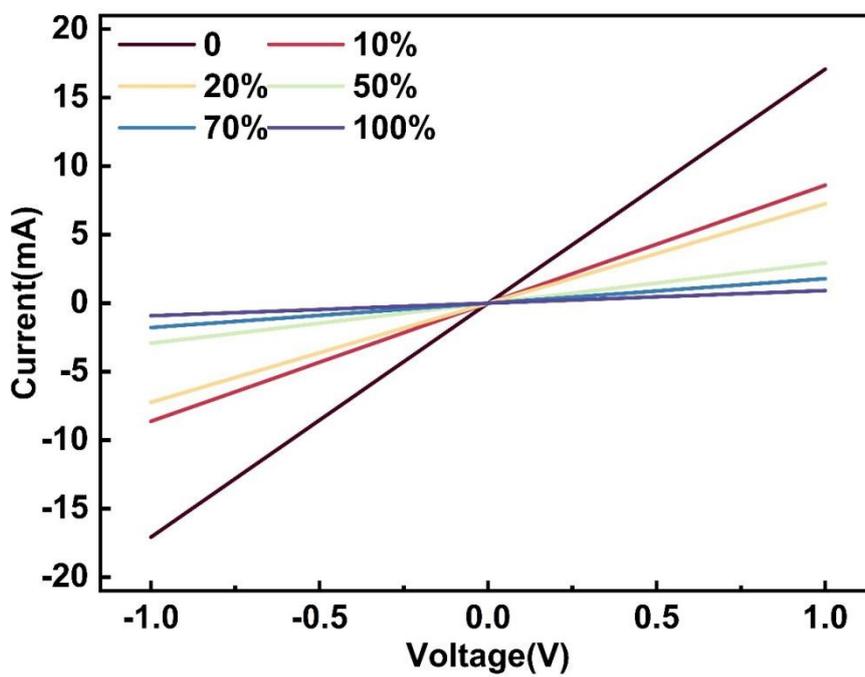


Figure S4 The I-V curves of KFMAS under different strains.

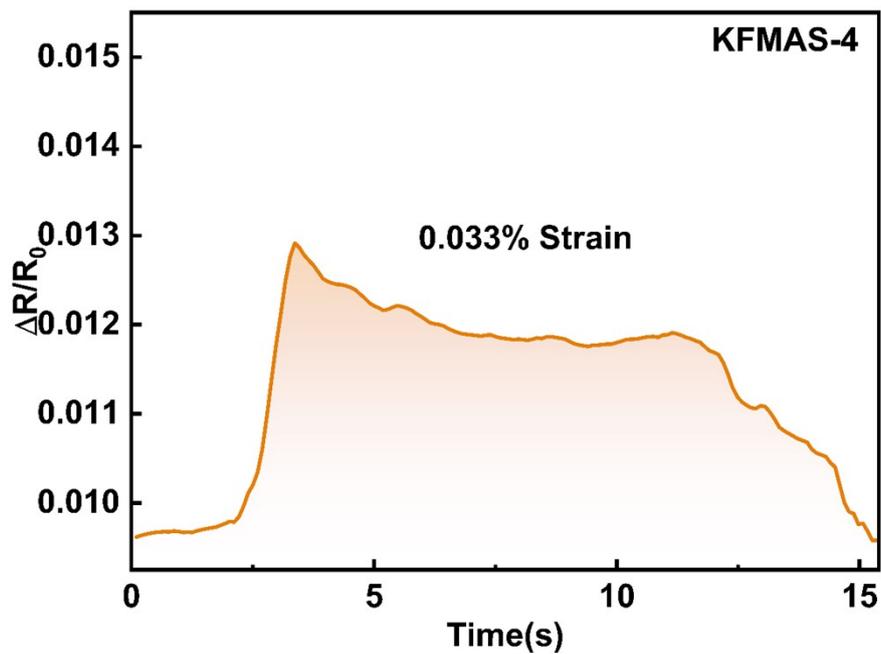


Figure S5 The minimum detectable strain curve of KFMAS-4.

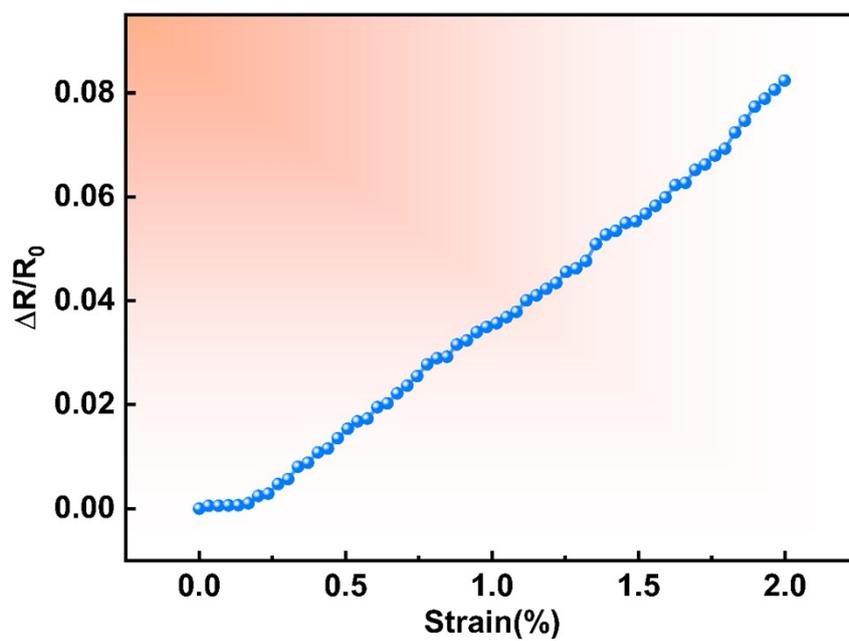


Figure S6 Resolution curve of KFMAS-4 under 2% strain.

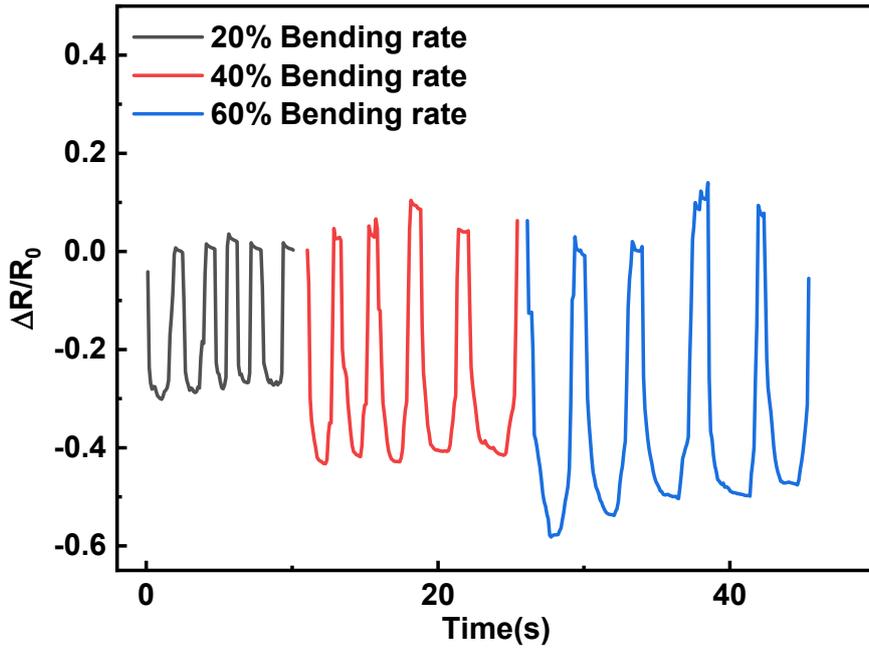


Figure S7 Repeated bending curve of KFMAS-4.

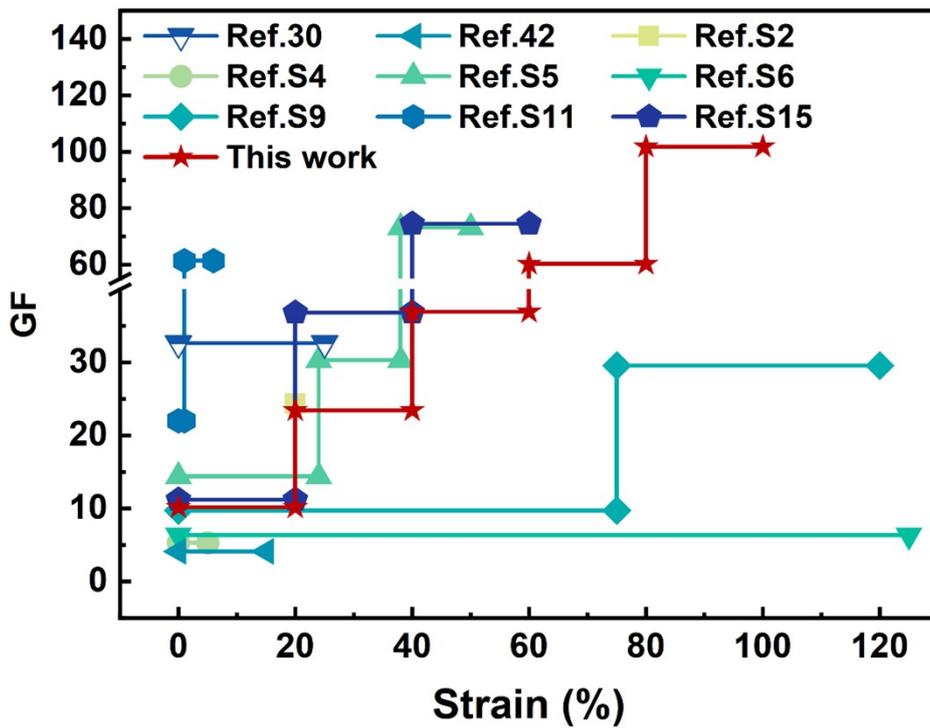


Figure S8 Comparison of flexible strain sensors with currently reported sensors.

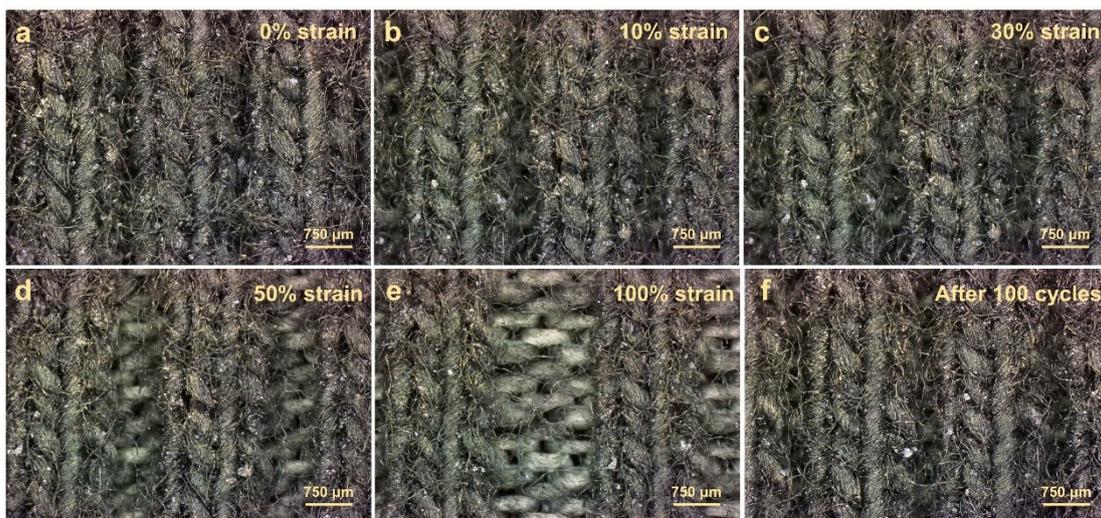


Figure S9 Optical microscopy images of the KFMAS at various tensile strain intervals: (a) 0%, (b) 10%, (c) 30%, (d) 50%, and (e) 100%. (f) Surface morphology after 100 cycles at 100% strain

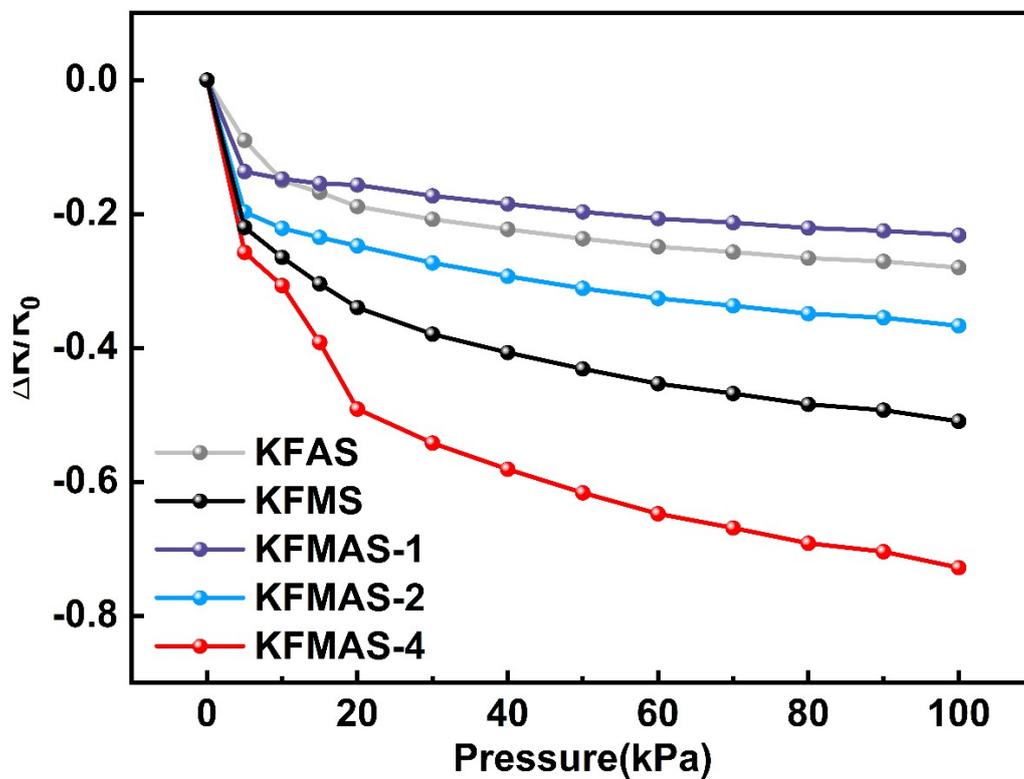


Figure S10 Compression sensitivity curves of KFAS, KFMS and KFMAS samples.

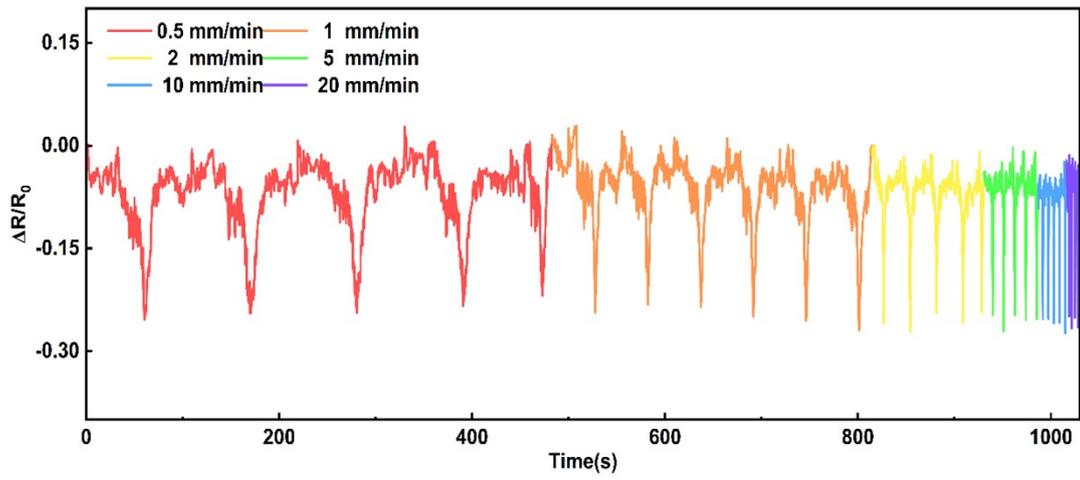


Figure S11 Dynamic compressive response of the KFMAS-4 sensor under varying loading rates ranging from 0.5 mm/min to 20 mm/min at a pressure of 10 kPa.

Table S1 Comparison of flexible strain sensors with currently reported sensors

| Materials | GF | Strain range | Response times(ms) | Linearity | Reference |
|--|---|---|--------------------|--|-----------|
| GNPs/double rib knitted fabric | 32.62 (0-25%, stretching) -25.32 (0-3 kPa, compression) -0.717 (5-20 kPa, compression) | >25% (stretching) 20 kPa (compression) | -- | Linear (R ² =0.96118, stretching) Two linear regions (R ₁ ² =0.94957, R ₂ ² =0.99366, compression) | 30 |
| Ti ₃ C ₂ T _x MXene/cotton fabric | 4.11 | 15% | -- | Linear | 42 |
| Ti ₃ C ₂ T _x MXene/P(VDF-TrFE) polymer nanofibers | 6.4 (0-21%) 32.5 (21-45%) 108.8 (45-66%) | 70% | 19 | Three linear regions | 48 |
| Ti ₃ C ₂ T _x MXene/nylon fabric | 24.35 (axial) 5.98 (radial) | 20% | -- | Nonlinear | 49 |
| AgNWs/Ti ₃ C ₂ T _x MXene/knitted PET fabric | 0.49 (0-100%) 2.67 (100-350%) 1.13 (350-450%) | 450% | 735 | Three linear regions | 50 |
| Ti ₃ C ₂ T _x MXene/polypyrrole/pure cotton yarn weft knitted fabric | -5.3±0.56 (0-5%) | 50% | -- | Nonlinear | 51 |
| Ti ₃ C ₂ T _x MXene-AgNWs/TPU | 14.4 (0-24%) 30.3 (24-38%) 73.2 (38-50%) | 350% | -- | Three linear regions | 52 |
| GaN alloy LMPs-Ti ₃ C ₂ T _x MXene-AgNWs/VHB | 6.339 | 125% | 110 | Linear (R ² =0.98224) | 53 |
| Ti ₃ C ₂ T _x MXene/Ga LM-CNT-PU fibers | 1.1367±0.08643 (0-90%) 0.27994±0.02284 (90-200%) | 200% | 120 | Two linear regions | 51 |
| AgNWs/AgNPs/Ti ₃ C ₂ T _x MXene/yarns fabrics | 309.10 (0-60%) 474.38 (60-150%) 872.79 (150-200%) | 200% | -- | Three linear regions | 52 |
| FeNWs/GNPs/interlock knitted fabric | 9.729 (0-75%) 29.553 (75-120%) | 120% | 298 | Two linear regions | 53 |
| Ti ₃ C ₂ T _x MXene/AgNWs/nonwovens | 57.7 (0-60%) 315.6 (60-80%) 1085 (80-100%) | 100% | 340 | Three linear regions | 54 |
| Ti ₃ C ₂ T _x MXene/polyester fabric | 9.7 (0-1%, course) 26.6 (1-3%, course) 6.6 (3-8%, course) 22.0 (0-1%, wale) 61.4 (1-6%, wale) | 8% (course) 6% (wale) | -- | Three linear regions (course) Two linear regions (wale) | 54 |

Continued Table S1 Comparison of flexible strain sensors with currently reported sensors.

| Materials | GF | Strain range | Responds times(ms) | Linearity | Reference |
|--|--|---|-------------------------------------|--|-----------|
| Cotton/stainless steel blend yarn knitted fabric | -3.7 (0-5%, course) -1 (5-40 %, course) -20 (0-5%, wale) -1.52 (5-40 %, wale) | 40% | -- | Two linear regions | s5 |
| Ti ₃ C ₂ T _x MXene/AgNWs/nylon/spandex blended knitted fabric | 12 (0-50%) 51 (50-90%) 267 (90-115%) | 115% | -- | Three linear regions | s6 |
| Carbon black nanoparticles/polyamide-spandex filaments elastic knitted fabric | 3.5 | 60% | - | Linear (R ² =0.998) | s7 |
| AgNWs/rGO/linen fabric | 11.2 (0-20%) 36.8 (20-40%) 74.5 (40-60%) | >60% | -- | Three linear regions | s8 |
| AgNPs/PPy/ Nylon-spandex webbing | 112.6 (0-35%) | 70% | 40 | Nonlinear | s9 |
| rGO/twill-weave pristine silk fabrics | 124.5 | 10% | -- | Linear | s10 |
| AgNWs/ Ti ₃ C ₂ T _x MXene /double rib knitted fabric | 10.15 (0-20%, stretching) | 415.99% (stretching) 100 kPa (compression) | 288(stretching) 576(compression) | Five linear regions and linear stretching) Two linear regions (R ₁ ² =0.98, R ₂ ² =0.97, compression) | This work |
| | 23.43 (20-40%, stretching) | | | | |
| | 36.91 (40-60%, stretching) | | | | |
| | 60.28 (60-80%, stretching) | | | | |
| | 101.80 (80-100%, stretching) | | | | |
| | 6.53 (0-3 kPa, compression) | | | | |
| 1.58 (5-20 kPa, compression) | | | | | |

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