

Electronic Supplementary information

## **Improvement of the Seebeck coefficient of PEDOT:PSS by chemical reduction combined with a novel method for its transfer using free-standing thin films**

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## Chemical species

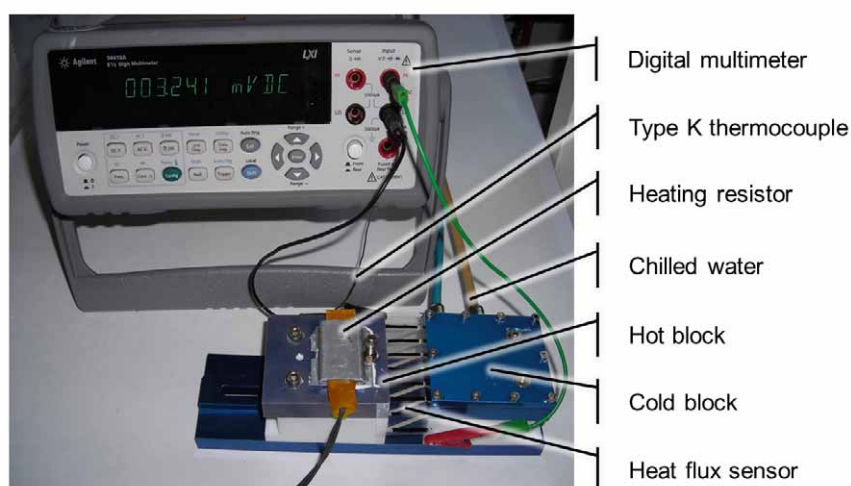
All chemical reagents were purchased from Sigma-Aldrich®.

- Sodium sulfite ( $\text{Na}_2\text{SO}_3$ ): CAS Number [7757-83-7]; purity  $\geq 98\%$
- Sodium thiosulfate ( $\text{Na}_2\text{S}_2\text{O}_3$ ) anhydrous: CAS Number [7772-98-7]; purity  $\geq 98.0\%$
- Hydrazine monohydrate ( $\text{NH}_2\text{NH}_2, \text{H}_2\text{O}$ ):  $\text{N}_2\text{H}_4$  64-65 %, reagent grade; CAS Number [7803-57-8]; purity 98%
- Tetrakis(dimethylamino)ethylene (TDAE): CAS Number [996-70-3]; purity not specified
- Sodium borohydride ( $\text{NaBH}_4$ ): CAS Number [16940-66-2]; purity  $\geq 99\%$
- Ethylene glycol (EG): CAS Number [107-21-1]; purity  $\geq 99\%$

## Characterization bench for heat flux sensors

Two anodized aluminum blocks are placed at the cold and hot ends of the sensors. The cold block is chilled by a flow of water at 15 °C. The hot block is heated by a resistor supplied by a voltage generator. A type K thermocouple located inside the block provides the temperature measurement. A digital multimeter (Agilent 34410A) connected at the bounds of the heat flow sensor measures the voltage across the sensor.

Despite exposure of the system to ambient conditions, measurements proved to be accurate and reproducible. The voltage across the sensor stabilizes correctly with the thermalization of the PEN support.



**Figure S1.** Characterization bench for heat flux sensors

### **Pictures of transferred PEDOT:PSS layers on differently shaped substrates**

The described transfer method allows considering geometrical forms that are impossible to implement by common polymer deposition methods.

Beside the flexible heat flux sensors described in this paper, other patterns were achieved. Examples are presented below in Figure S2.



**Figure S2.** Pictures of PEDOT:PSS thick films transferred on thick glass and a curved plastic surface.

## Electrical characterization of reduced layers

The electrical conductivity of reduced layers was measured by the 4 probes technique.

The thickness of the layers was measured with a profilometer.

The decrease of electrical conductivity during the reducing process depends on the chemical nature of the reducing agent and the order in which the reducing and doping steps were performed (see table below).

Reducing agent	EG-dipping	Seebeck coefficient [ $\mu\text{V/K}$ ]	Electrical Conductivity [S/cm]
None	a	18	9.6
None	b	18	714.2
$\text{Na}_2\text{S}_2\text{O}_3$	b	59	234.7
TDAE	b	43	3.7
$\text{Na}_2\text{SO}_3$	b	70	139.7
Hydrazine	b	92	0.1
$\text{NaBH}_4$	b	104	0.1
$\text{Na}_2\text{S}_2\text{O}_3$	c	37	106.4
TDAE	c	161	0.2
$\text{Na}_2\text{SO}_3$	c	39	178.6
Hydrazine	c	153	0.7
$\text{NaBH}_4$	c	53	11.3

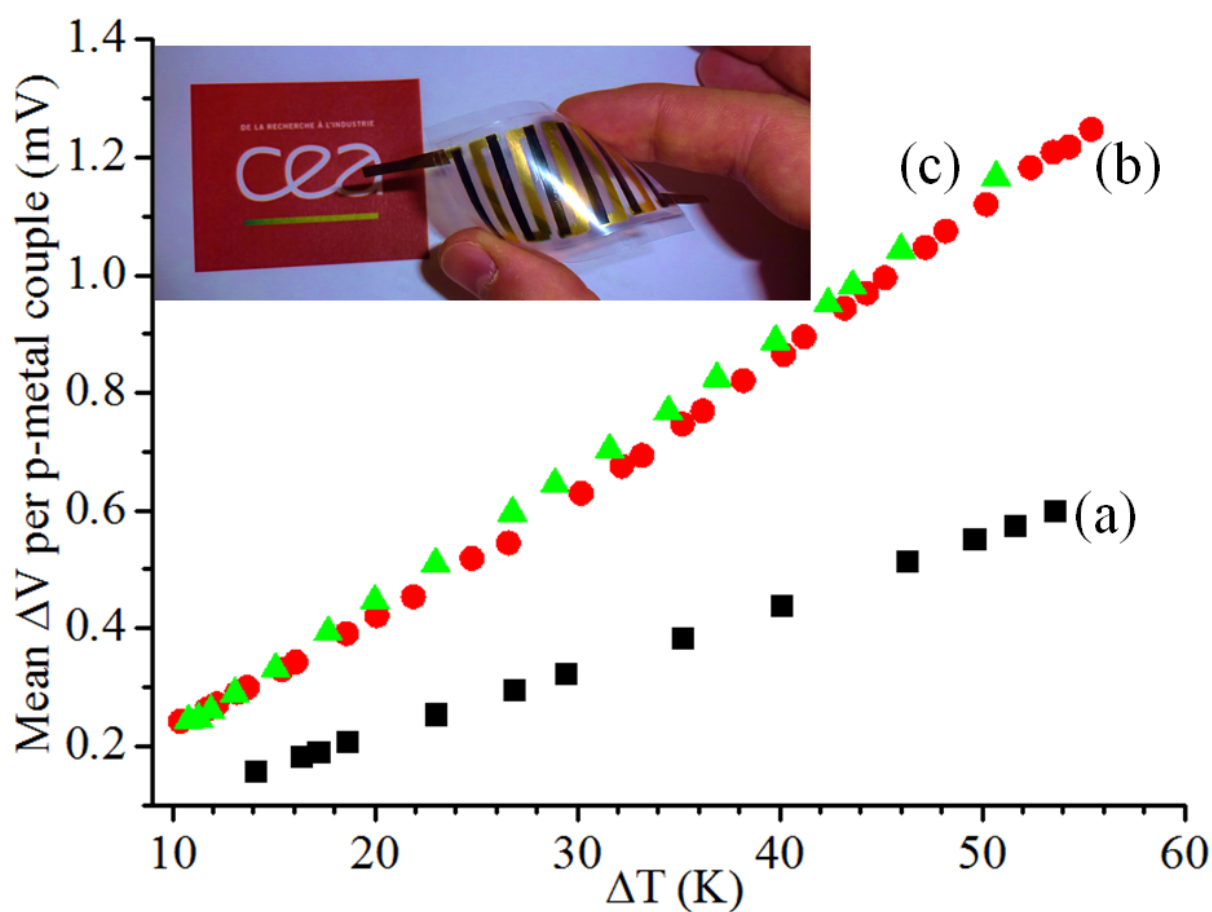
<sup>a</sup> EG dipping not performed, <sup>b</sup> EG dipping performed after the reduction step, <sup>c</sup> EG dipping performed before the reduction step

**Figure S3.** Electrical conductivity of PEDOT:PSS thick films exposed to reducing treatments.

### *p*-type heat flux sensor

*p*-metal devices were developed to improve the transfer of PEDOT:PSS legs on the heat flux sensor support. The following figure shows the voltage across *p*-type sensors versus the temperature difference.

The efficiency enhancement is similar regardless the reducing agent. The ageing of the samples is probably the cause of this phenomenon, as the stable oxidation level was found to be the same for all tested reducing species.



**Figure S4.** Voltage generation of a *p*-metal junction in (a) *p*-type only devices composed of PEDOT:PSS; (b)  $\text{NaBH}_4$ -treated PEDOT:PSS; (c) TDAE-treated PEDOT:PSS.