Supporting Information

Long-Duration Transmission of Information with Infofuses

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Thermodynamic Efficiency of Infofuse

To calculate the efficiency (total transmitted energy from the burning metal salts/total energy of combustion of the nitrocellulose) of the infofuse, we compared the intensity of emission of a burning infofuse with a green light-emitting diode (LED) of known luminous intensity. At a given distance and at an optimized angle, we measured the integrated intensities of burning fuses and a green LED with known candela output. Then, using the cone angle of the LED (estimated by shining the LED on a piece of paper with trigonometry), the isotropic intensity of the LED has been determined. Comparing the intensity of burning fuses and the LED, we estimated the maximal power of each pulse of an infofuse to be ~ 1 mW.

Heat of combustion of nitrocellulose:[20] 4.2 kJ/g = 4200 mJ/mg

Density of nitrocellulose: 1.66 g/cm^3

For a fuse with width of 1 mm and thickness of 100 µm, mass of a fuse per pulse is (pulse rate of 10 Hz and burning rate of 2.5 cm/s): (100 µm) × (1 mm) × (2.5 mm) × (1.66 g/cm^3) ≈ 0.3 mg

$$\text{Efficiency} = \frac{\text{Total transmitted energy from the burning metal salts}}{\text{Total energy of combustion of the nitrocellulose}}$$

$$= \frac{(1\ \text{mJ/s}) \times (0.1\ \text{s/pulse}) \times (1\ \text{pulse}\ /0.3\ \text{mg})}{4200\ \text{mJ/mg}} \times 100\ \approx 0.01\ \%$$

Figure S1

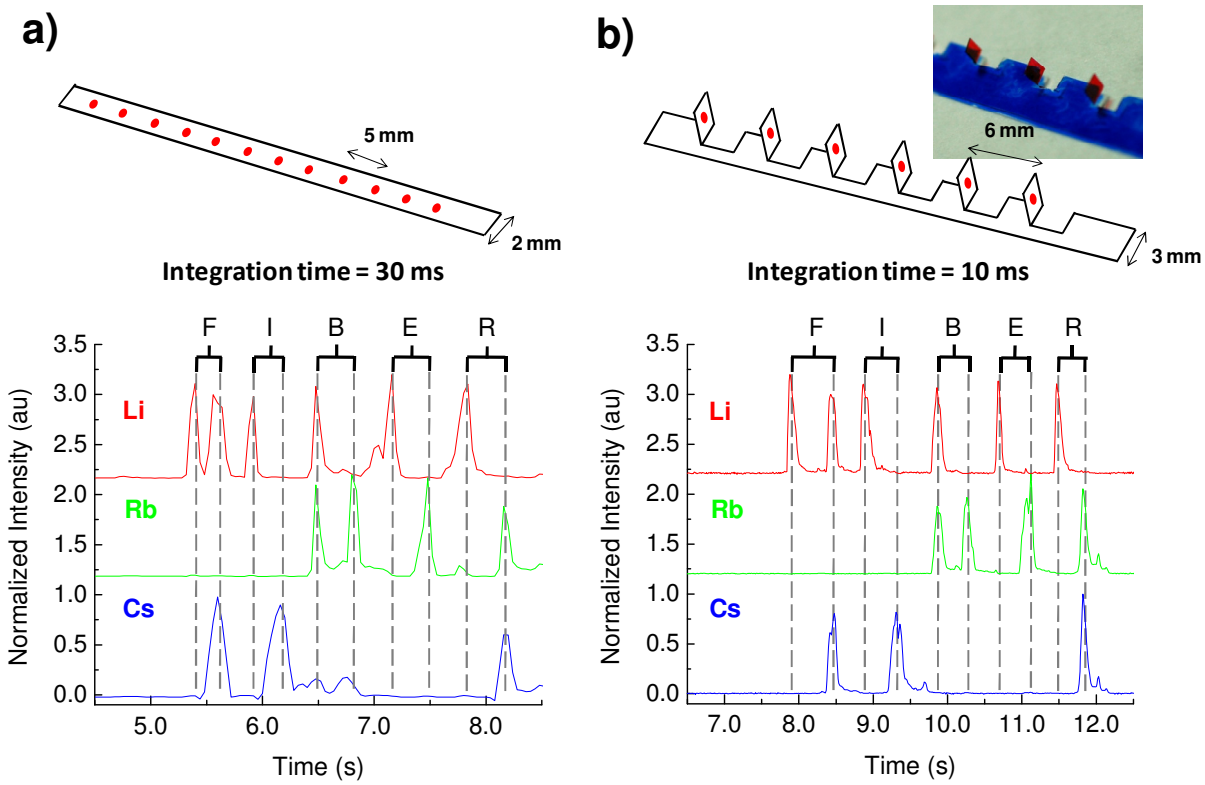

Figure S1. Two strategies to generate a single pulse from a single spot for flat fuses on fiberglass. a) Using long integration time (30 – 40 ms) for collecting data: schematic diagram of a flat fuse (top), and transmitted light detected from a flat fuse on fiberglass (bottom). b) Fabricating fuses so that the NC supporting the metal salts could have little interaction with ah substrate: schematic diagram of a fabricated fuse (top), and transmitted light detected from a fabricated fuse (bottom); Inset image shows a blowup photograph of a fabricated fuse. We colored the fuse blue (part that sits on fiberglass) and red (part where metal salts are deposited) with permanent marker for easy visualization. In all schematic diagrams of fuses, red dots indicate deposited metal salts. In the encoding scheme used here, two consecutive optical pulses represent one alphanumeric character.

Figure S2

Figure S2. Photographs of 3 mm-wide strips of nitrocellulose burning on a film of Kapton. The folded strip (folded once along its long axis) burned completely, while the flat strip extinguished (by heat transfer from the hot zone to the Kapton substrate).

Figure S3

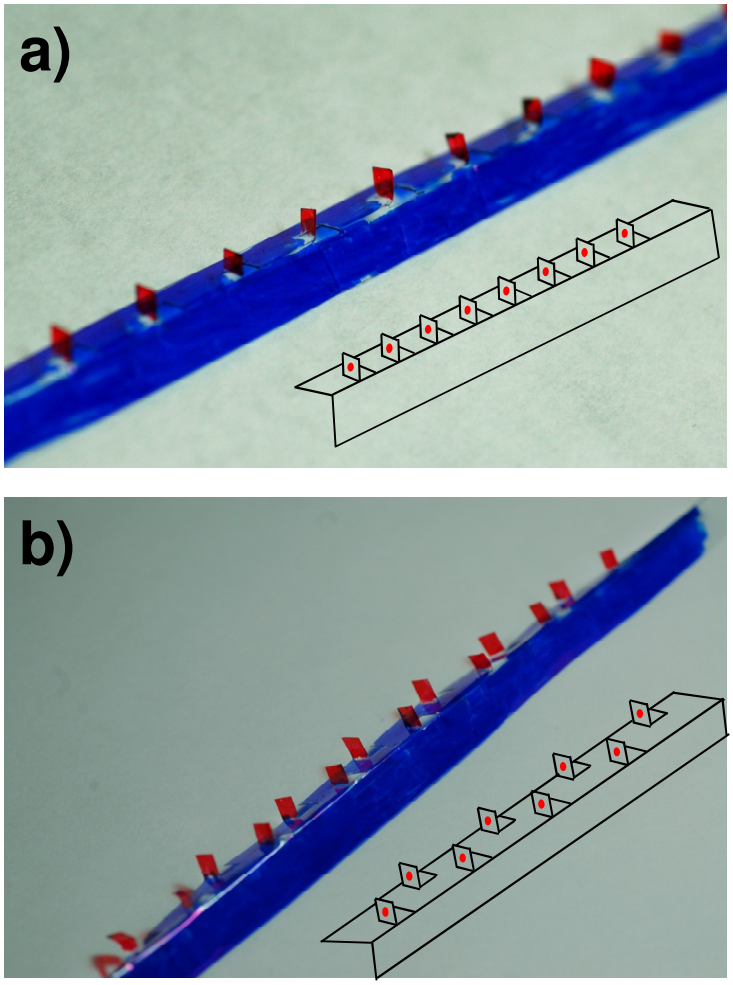

Figure S3. Photographs of fabricated fuses: a) a fabricated fuse in Figure 2b, b) a fabricated fuse in Figure 2c.

Figure S4

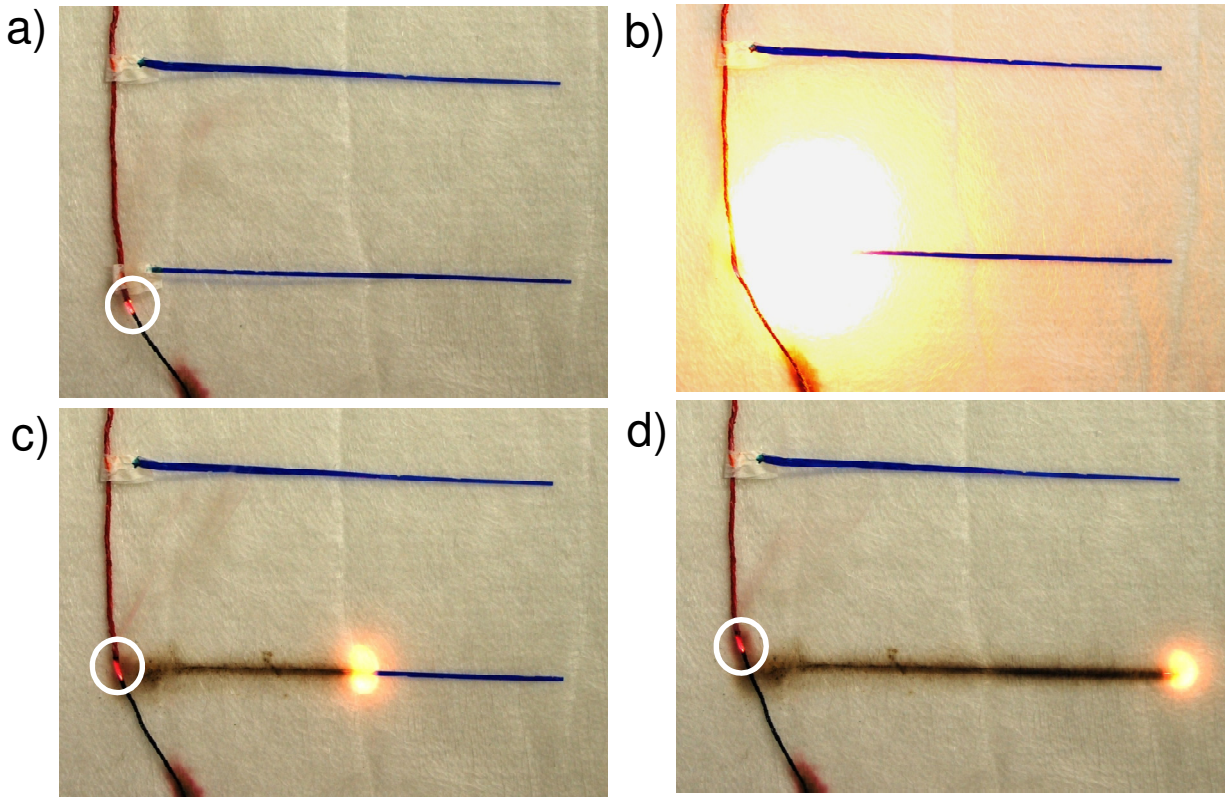

Figure S4. Pictures of a burning two-speed infofuse resting on fiberglass: a) as the propagating hot ember of the SlowFuse (circled) approached flash paper (nitrated tissue paper), b) as the flash paper burned, c and d) as the FastFuse burned to completion and the burning ember of the SlowFuse continued to propagate (circled). We colored the SlowFuse red and FastFuses blue with permanent marker for easy visualization. The widths of the SlowFuse and FastFuses are ~ 1 mm, and the lengths of the FastFuses are ~ 7.5 cm.

Figure S5

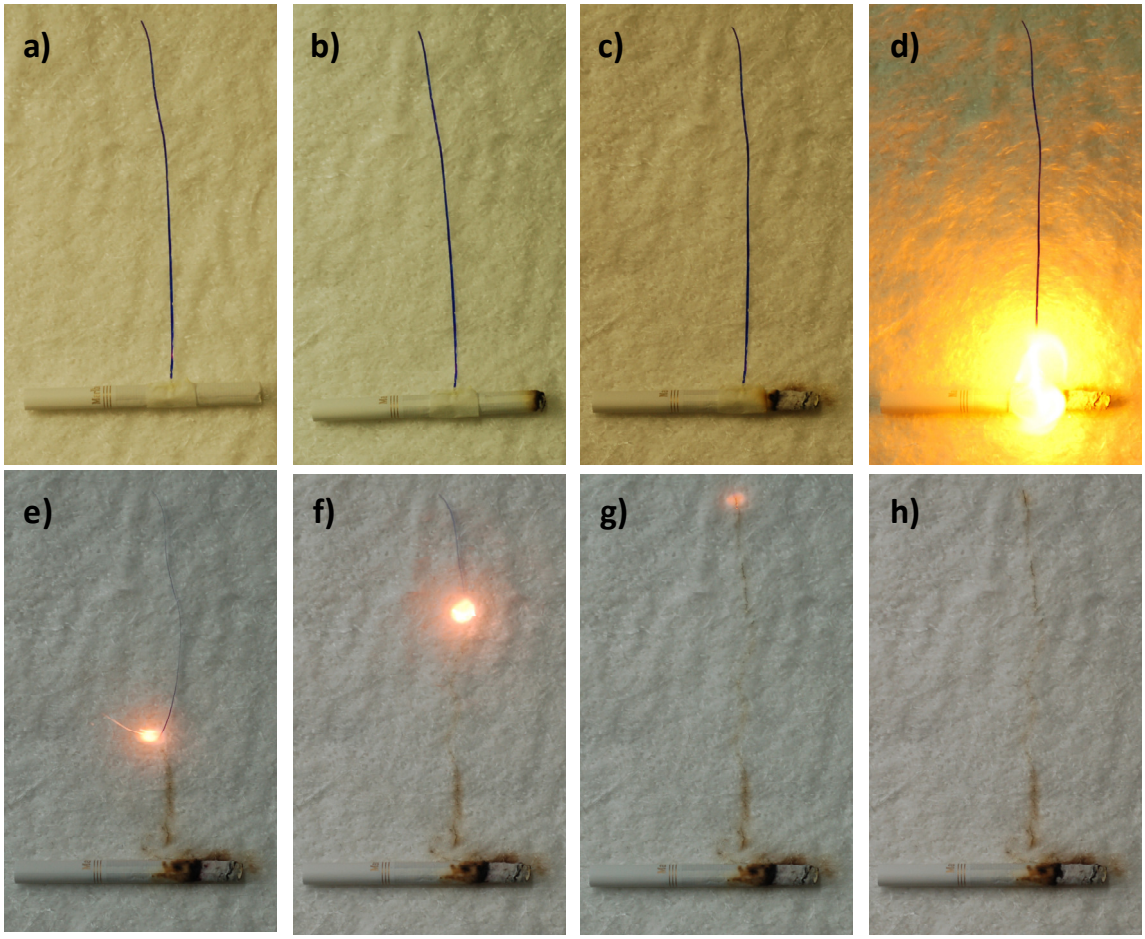

Figure S5. Using a cigarette as the SlowFuse in a two-speed infofuse. The hot zone of the cigarette ignited the flash paper/NaN_3 combination (d) (flash paper was wrapped around the cigarette with FastFuse using NaN_3 powder and acetone solution of nitrocellulose as glue), which in turn ignited a nitrocellulose FastFuse. The cigarette continued to burn after igniting the FastFuse (the burning rate of cigarette was 0.7 – 0.8 cm/min).