Flexible Touch-Panels for Flexible Displays

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What / Who is "Walker Mobile, LLC"?

Geoff Walker's consulting company

2001-2007: Full-time (7 years)
2011-2012: Full-time (1 year)
2015-present: Part-time (retired)

Agenda

- **Introduction**
- **State-of-the-art**
- **Flexible touch-panel considerations**
  - Transparent conductors
  - Substrates
  - Touch surface
  - Electrode pattern
  - Finger-to-electrode spacing
  - Stack-up
  - Proximity to display
  - Attachment to display
  - Controller
- **Conclusions**

Introduction

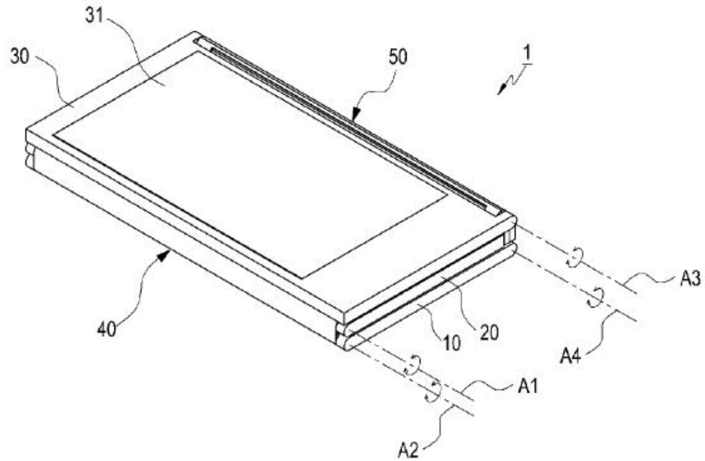
- **Definition of "flexible"**
  - Conformable in manufacturing (e.g., Galaxy S6 Edge)
  - Bendable (radius = 50+ mm)
  - Rollable (radius = 5-10 mm)
  - **Foldable** (radius = 1-5 mm)
- **Display-technology assumption**
  - **OLED**, the only realistic flexible display
- **Touch-technology assumption**
  - **P-cap**, not digital resistive behind the display (e.g., R&D CORE) or any other emerging solution

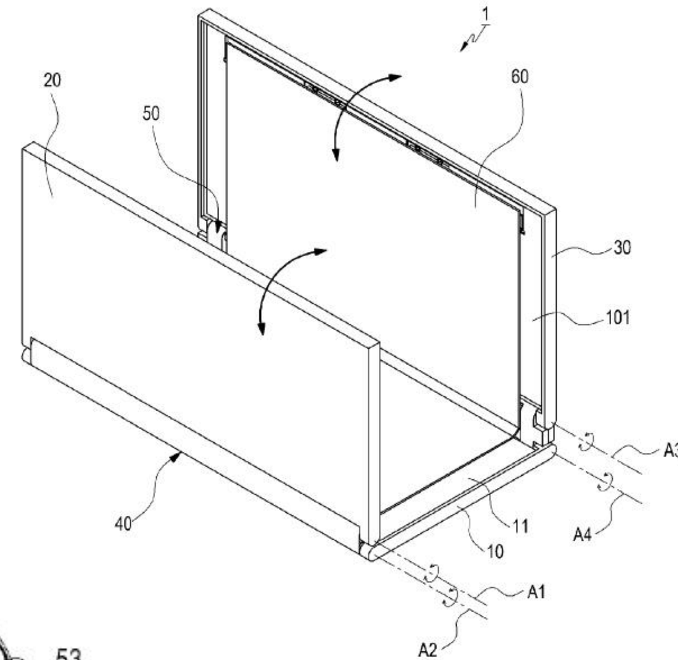
State-of-the-Art…1

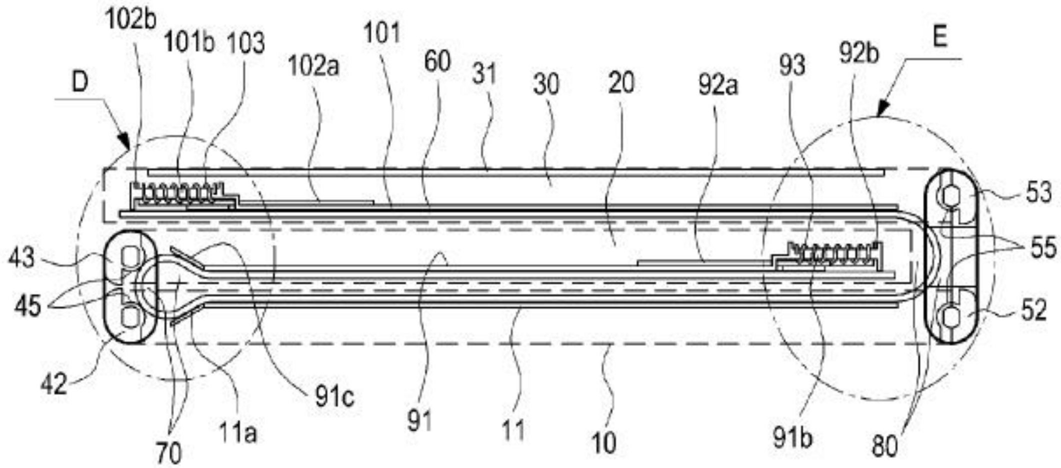
- **SEL's 8.7-inch "Foldable Display" proto (Oct. 2014)**
  - OLED <100 µm thick; 100K bends; FHD @ 254 ppi; P-cap touch

State-of-the-Art…2

- Samsung's design-patent for a "tri-fold phone"

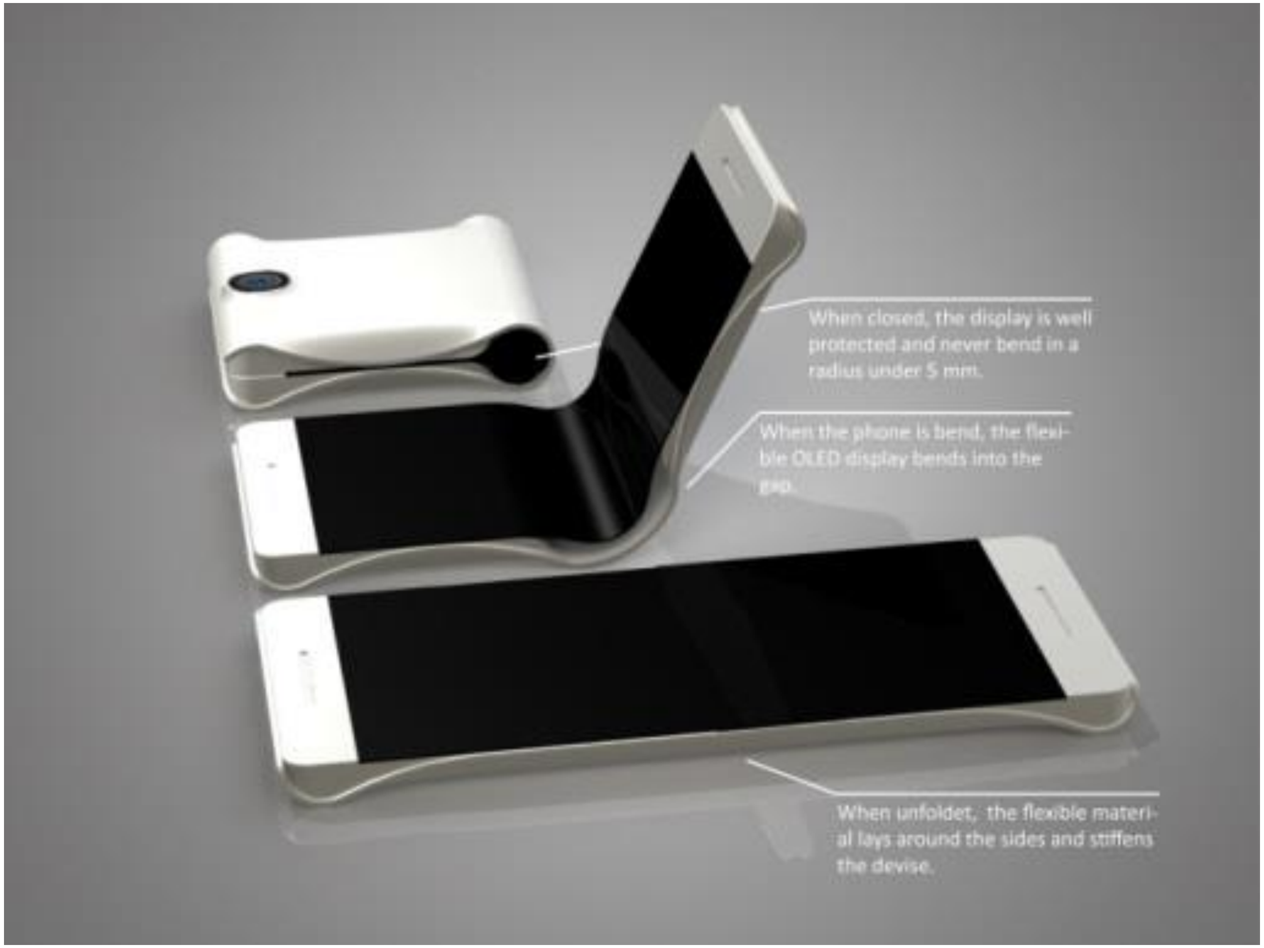






State-of-the-Art…3

❖ **Samsung's design-patent for a "flip phone"**



Radius
< 5 mm

Transparent Conductors

- **Carbon nanotubes (e.g., Canatu's CNBs)**
  - 100K bends at 1 mm radius, but with +65% -38% resistance change
  - Very low reflectivity is an additional benefit
- **Silver nanowires (e.g., Cambrios)**
  - 100K bends at 3 mm radius
  - Most readily available solution
- **PEDOT conductive polymer (e.g., Heraeus)**
  - 100K bends at 3 mm radius
  - Highest sheet resistance (similar to ITO)
- **Copper or silver metal-mesh (e.g., Unipixel/Atmel)**
  - 157K bends at 10 mm radius
  - Least flexibility but offers excellent touch performance

Substrate & Touch Surface

- **Substrate**
  - **20-30 μm PET** (with handling difficulties)
  - 20 μm PI (more expensive; heat-resistance not needed)
- **Touch surface**
  - **Durability is a BIG problem**
    - Hardcoat (6H to 9H) can provide very good scratch-resistance
    - Nothing can provide **deformability resistance**
    - OLED display is also at risk of being damaged by touches

Electrodes & Spacing

- **Electrode pattern**
  - **Single-layer** "caterpillar" pattern (up to ~7 inches) is thinnest and lowest-cost solution
  - Two layers with dielectric (thinner) or on two sides of film (thicker)
  - Pattern is not a critical element…
- **Spacing between electrodes and finger**
  - Smallest current spacing supported by today's controllers is ~2 mm with plastic cover-glass (4 mm with glass)
  - **Poster CP2-011** simulation suggests that crosstalk will limit the minimum spacing to 107 µm
  - I believe that this problem has already been solved, but I can't point to a source

Stack-Up

- **Stack-up depends on the choice of materials**
  - Here's what Canatu (using CNTs) suggests:

Total Window+sensor:

40 um

Air	
HC/AR/AG	3 um
PET	23 um
Décor	9 um
CNB Touch layer	0.05 um
Ag traces	5 um
OCA	50 um
Display	

  - If the display is ~100 µm (like in SEL's proto), then **the total thickness is less than 200 µm**, which is considerably thinner than just the flexible OLED in Samsung's & LG's curved phones (500-700 µm)

Proximity & Attachment to OLED

- **Having the touch-panel electrodes a few microns away from the OLED display creates problems with noise and parasitic capacitance**
  - **AUO demoed a solution** at SID Display Week 2014 (with the electrodes on the underneath of the OLED encapsulation glass)
    - "The OLED top-electrodes act as a shield for the TFT layer, so the noise level seen by the touch-sensor is less than with an LCD"
    - "Clever OLED driving optimized for touch-sensing" is the key
- **Attaching the touch-panel to the OLED is not a big issue**
  - OCA is the easiest solution
  - In theory, the touch electrodes could even be deposited ("printed") directly on top of the OLED
  - **Strain management and reduced flexibility** are the main issues

Touch Controller

- **Specialized algorithms are likely to be needed to deal with spacing and proximity issues**
  - No surprise, but probably **not as difficult as in-cell**

Conclusions

- **Some flexible touch-panels have been built already**
  - Nothing's in mass production, but building a flexible touch-panel is clearly easier than building a flexible OLED
- **The durability of the touch surface is a BIG problem**
  - PC (polycarbonate) isn't accepted by the market yet as a cover-glass material; 30-µm PET will have an even lower acceptance
- **Once a mainstream application for a flexible OLED exists, then a flexible touch-panel will also exist**
  - My prediction is a folding display for a smartphone
  - Triple the screen area, OR half the X-Y and double the Z

Thank You!

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