Electrostatic Roll-up Blind Array for Building Energy Management Systems

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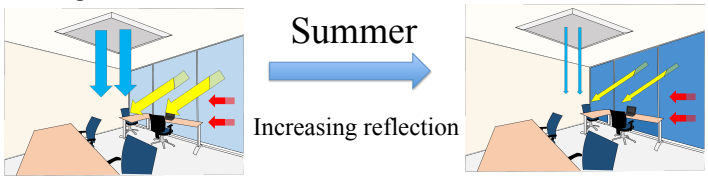
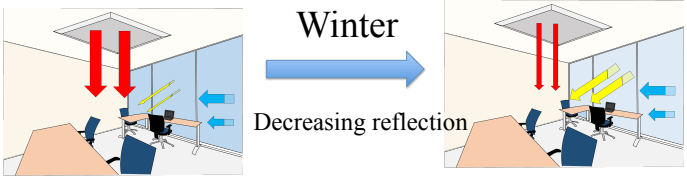
Active windows efficiently suppress the energy consumption of building by controlling incoming sunlight. We investigated a use of roll-up shutters for reconfigurable windows. Roll-up shutter automatically tilt up from the substrate by the built-in stress due to the difference of coefficient of thermal expansion coefficients between two materials for a unimorph structure. Process and structures are compatible with the typical TFT technology used in the liquid crystal displays.

Active Window

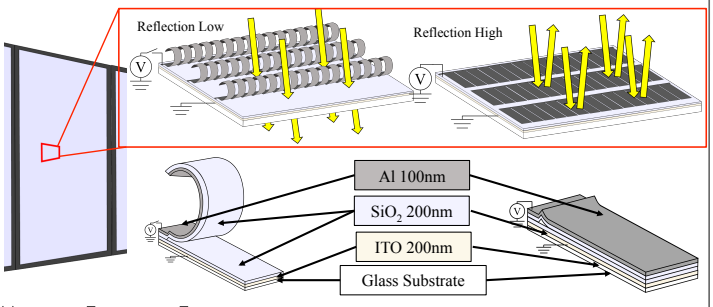
Active windows efficiently suppress the energy consumption of house by controlling the incoming sunlight.

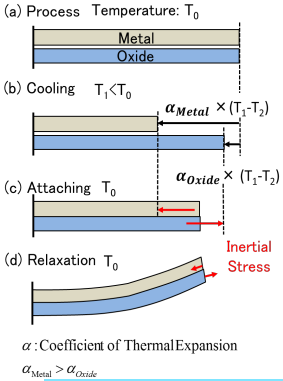




Micro Roll-up Blind Array

Micro Roll-up Blind Array can realize active windows. Normally, Reflection of active windows is low because the blinds are opened by the built-in stress. When a voltage is applied voltage between Al and ITO, reflection becomes high because of the shinny Al surface covering the entire surface of the substrate.

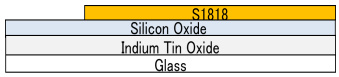




- The unimorph structure composed of two materials has residual stress when cooled down from the process temperature to the operation room temperature.
- The unimorph structure was curled up due to the residual stress, when no voltage is applied.

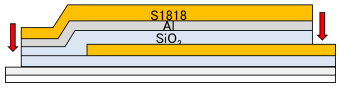
Fabrication

(a) Lithography

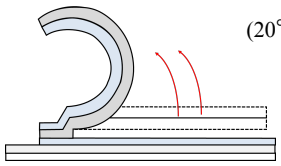


(b) Al and SiO_2 sputtering (180℃)

(c) Etching Al and SiO_2

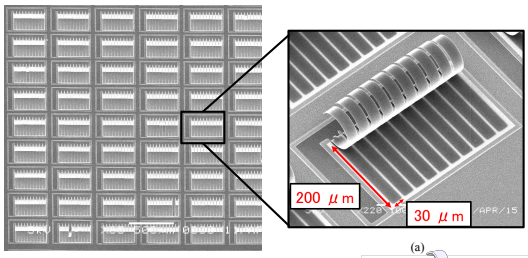


(d) O_2Ashing (20℃)

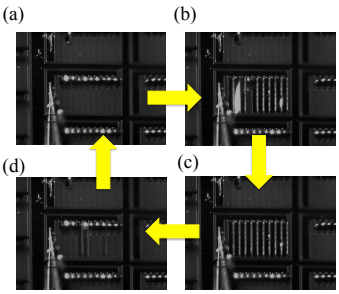


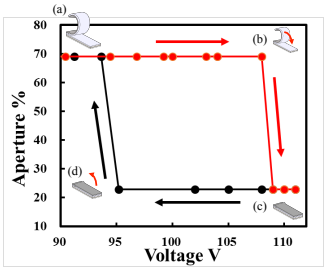
- Silicon Oxide and aluminum layers are formed at a high temperate (180 ℃) by sputtering.
- The blind is automatically bent up when photoresist as a sacrificial layer is removed by O_2ashing, because the device temperature is lower than 180 ℃.
- The process and structures are compatible with the typical TFT technology used in the liquid crystal displays.

Result



- Yield Ratio 99 %
- Radius of Curvature 55 um





- Pull-in Voltage @(b) 109 V
- Release Voltage @(d) 94 V

Future Work

The process and structures are compatible with the typical TFT technology used in the liquid crystal displays. We will develop a MEMS blind array on a TFT substrate for random access control.

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